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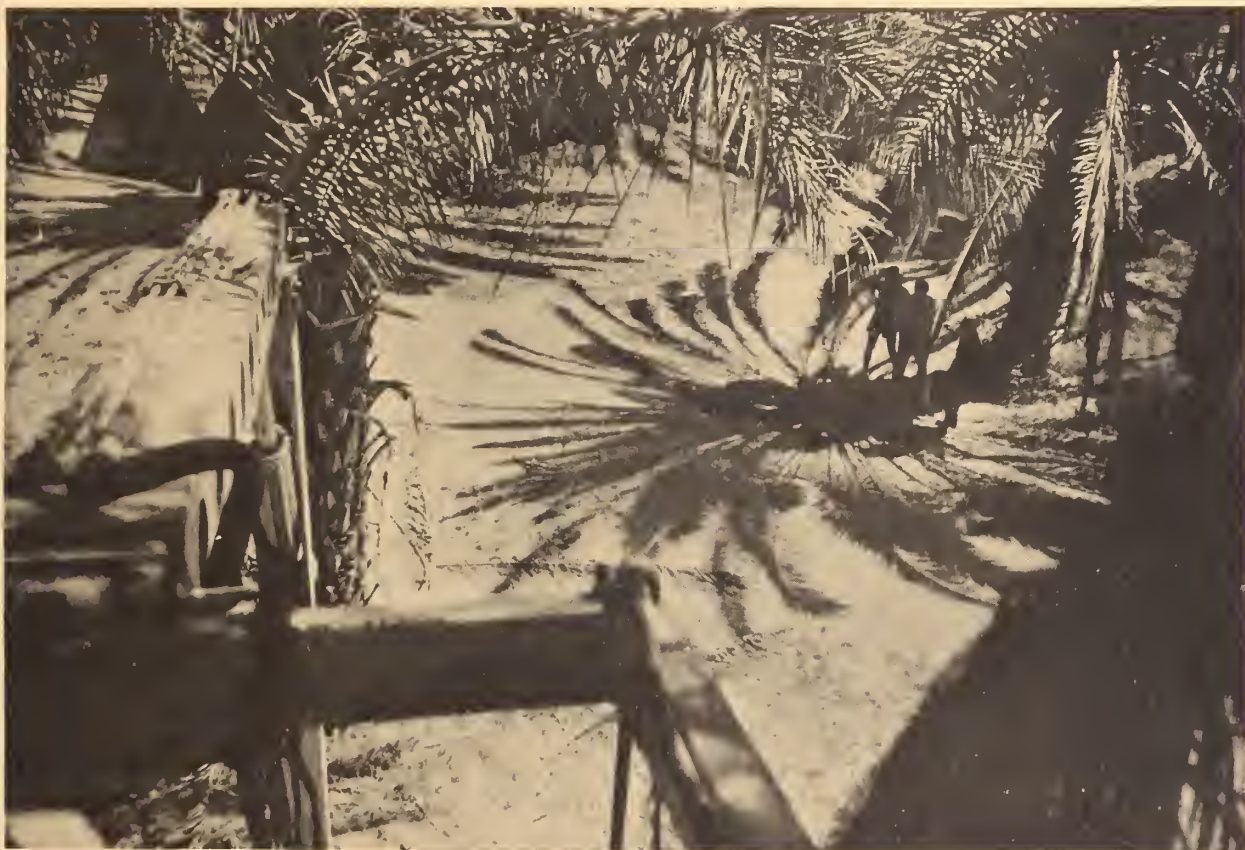
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FIFTY-FIRST ANNUAL
DATE GROWERS' INSTITUTE

Held in
COACHELLA VALLEY, CALIFORNIA

March 15, 1974

VOLUME 51

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DRIP VERSUS SPRINKLER IRRIGATION OF DATE PALMS

O. REUVENI

Contribution from the Agricultural Research Organization,

The Volcani Center, Rishon Le Ziyon, Israel. 1974 Series, No. 264-E.

ABSTRACT

A long-term irrigation experiment, comparing sprinkler and drip methods was conducted for 5 years on mature, bearing Deglet Noor date palms. Under drip irrigation two densities of drippers were compared (12 or 24 drippers per tree, dripper discharge rate 10 l/h). Drip was superior to sprinkler irrigation, as expressed in greater annual leaf and bunch production, fruit size and total yield. The advantage was explained by a higher water availability, i.e., drip irrigation uses water more efficiently. Date palm trees could be grown and made to yield when only a small part of the area between trees was wetted. The advantage of using drip irrigation under marginal conditions of saline water, high water table and atmospheric dryness, the conditions under which the experiment was carried out, is discussed.

Date Inst. Rep. 51:3

A long-term irrigation experiment on mature, bearing date palms was initiated in 1968 at Yotvata in the Arava Valley of Israel (2). At that location a highly saline (8,000-10,000 mg chloride/l) water table exists, without a drainage system. The water used for irrigation is relatively saline (550-600 mg chloride/l) and its economic utilization is a definite requirement.

The drip irrigation technique seemed to be promising for use in this area, since water usage is more efficient, and the small output (albeit over a long period) might prevent a sudden rise in the water table, as compared with other irrigation methods, such as basin or sprinkler irrigation. When using a drip irrigation system, only a small area of the ground is wetted, and the question was whether mature date palms would grow and yield well when only a part of the entire space between trees was wetted. Two rates of drip irrigation which wetted limited areas were compared. Preliminary data reported in 1971 (2) suggested that drip irrigation was superior to sprinkler irrigation. The data obtained during 1970-1973 are presented herein.

MATERIALS AND METHODS

The experiment was conducted in a 'Deglet Noor' date garden at Yotvata, planted in 1958, on a sandy loess soil. A description of the climatic conditions and of the properties of the water used for irrigation were reported by Shmueli and Goldberg (3).

The original irrigation systems compared were described in detail elsewhere (2), but the treatments consisted essentially of:

- O - One line of drippers (discharge rate, 10 l/h) per row, with 12 drippers, 75 cm apart, per tree; wetting the smallest area between the trees.
- T - Two parallel lines per row, 1 m apart, of 12 drippers per tree (total = 24 drippers), 75 cm apart in the line; Wetting a limited area between the trees, but greater than O.
- S - Sprinklers which wet the entire surface between trees. Sprinklers were covered with cans in late summer to make large drippers, with the aim of preventing a rise in relative humidity, which might induce fruit checking.

The other materials and methods outlined in 1971 (2) have remained in use, except when noted below as different. Beginning in 1971, drip-irrigated trees were fertilized once a week with a pre-calculated amount of fertilizer proportional to the amount of water given. Fertilizers were not applied to trees during the ripening and harvesting period, in September and October. An amount of fertilizer equal to that used annually on drip-irrigated trees was distributed in 3 to 5 broadcast applications to sprinkler-irrigated trees. Table 1 shows the amounts of water and fertilizers given to each tree. Leaves from all 12 trees in each plot were sampled annually in mid-April for analyses.

Fruit thinning was done as in previous years to provide 900-1000 fruits per bunch, but all of the bunches were left on the trees. The yield of each tree was determined separately. The fruits were thoroughly mixed and a random sample of 1000 fruits per tree was weighed and graded.

RESULTS

Results of N, P, K content in leaves are presented in Table 2. A steady increase in N content of pinnae, with some between-year variations in relative values, was found. A fairly uniform N content in pinnae of all treatments was found in 1973. Phosphorus content did not vary appreciably during the four years of analyses. Potassium content varied annually (non-significant) between treatments except in 1973, when the pinnae of drip-irrigated trees had significantly more K than those of sprinkler-irrigated trees.

All irrigation treatments afforded an improvement in annual leaf, flower and bunch production, which suggests that the trees were still recovering from neglect prior to 1968. Leaf production appeared to be stabilized in 1972 and 1973. Drip irrigation provided a significantly greater increase in leaf, flower and bunch production than sprinkler irrigation (Table 3 and Fig. 1). Moreover, one line of drippers was as satisfactory as two lines.

The yield of drip-irrigated trees as compared with sprinkler-irrigated ones, was significantly higher in 3 out of 4 years for one line, and in 2 out of 4 years for two lines of drippers. No significance was found in yield during the 4 years between one and two lines of drippers (Table 4).

Individual fruit weights were significantly higher for drip-irrigated trees than for those receiving sprinkler irrigation, and the increased weight was reflected also in the total yields per treatment (Table 4).

Fruit quality (Table 5) was significantly better on drip- than on sprinkler-irrigated trees in 3 out of 4 years, but there were no important differences in quality between trees irrigated with one and two lines of drippers. Percentages of grade B and dry fruit varied from year to year but were not of commercial importance except in 1970 and 1971, despite the significant differences among treatments. The category "dry" refers to post-maturity drying, and not to pre-harvested drying or shriveling. In years where the harvest was delayed, the percentage of dry fruit increased. Sprinkler-irrigated trees were always harvested first, since their fruit ripened earlier than those irrigated with drippers.

DISCUSSION

Aldrich and Crawford (1) showed that the rate of growth of the spike leaf might serve as a sensitive index of water deficits. From measurements of the spike leaf elongation (Fig. 1) it can be concluded that more water was available to drip-irrigated trees than to sprinkler-irrigated ones. This was pronounced even when a smaller amount of water was given during the first 2 years. Although the mineral content of the leaves (Table 2) was significantly different in some years between the different irrigation treatments, it can not explain the difference in vegetative growth. The greater vegetative

Table 1. Annual amount of water and fertilizer applied to drip or sprinkler-irrigated date palms

Year	Water applied (m ³ /tree) ^a	Fertilizer applied		
		Kind	N (kg/tree)	K (kg/tree)
1970	150	Ammonium sulfate	1.6	
1971	195	Ammonium sulfate, potassium nitrate, urea, potassium chloride	3.6	9.2
1972	205	Urea	2.4	
1973	190	Urea, potassium nitrate	5.1	10.0

^a Conversion of m³ to acre feet: 150 = 4.8; 195 = 6.3; 205 = 6.3; 190 = 6.2.

Table 2. Average content of N, P, K in pinnae of date palms irrigated by one dripper line (O), two dripper lines (T), or sprinklers (S)

Treatment	Percent of dry matter											
	N				P				K			
	1970	1971	1972	1973	1970	1971	1972	1973	1970	1971	1972	1973
O	1.35	1.46	1.64	1.73	0.09	0.08	0.08	0.09	0.64	0.58	0.68	0.73
T	1.26	1.40	1.65	1.71	0.08	0.08	0.08	0.09	0.64	0.55	0.68	0.77
S	1.48	1.53	1.56	1.68	0.08	0.08	0.08	0.09	0.61	0.54	0.72	0.63
Significance ^a	O/S/T	S/OT	OT/S	NS	NS	NS	NS	NS	NS	NS	NS	TO/S

^a NS = No significant difference among treatments.

OT/S = Significant (5% level) difference between treatments to the left and to the right of the stroke.

O/T/S = Significant (5% level) differences among treatments, in descending order from left to right.

TO/ST = Significant (5% level) difference between O and S, but no significance between S and T or O and T.

Table 3. Annual average production of leaves, inflorescences and bunches harvested from date palms irrigated by one dripper line (O), two dripper lines (T), or sprinklers (S)

Treatment	Leaves (No.)				Inflorescences (No.)				Bunches harvested (No.)			
	1970	1971	1972	1973	1970	1971	1972	1973 ^a	1970	1971	1972	1973
O	24.4	27.7	31.9	32.0	11.9	14.2	16.9	—	11.8	14.0	16.3	18.7
T	22.4	28.5	32.6	31.6	10.3	13.5	17.2	—	10.2	13.4	16.4	19.0
S	22.2	26.1	27.5	27.1	11.3	13.8	15.1	—	11.2	13.3	14.4	16.5
Significance ^b	NS	OT/S	OT/S	OT/S	NS	NS	OT/S	—	NS	NS	OT/S	OT/S

^a Missing data.

^b See footnote to Table 2.

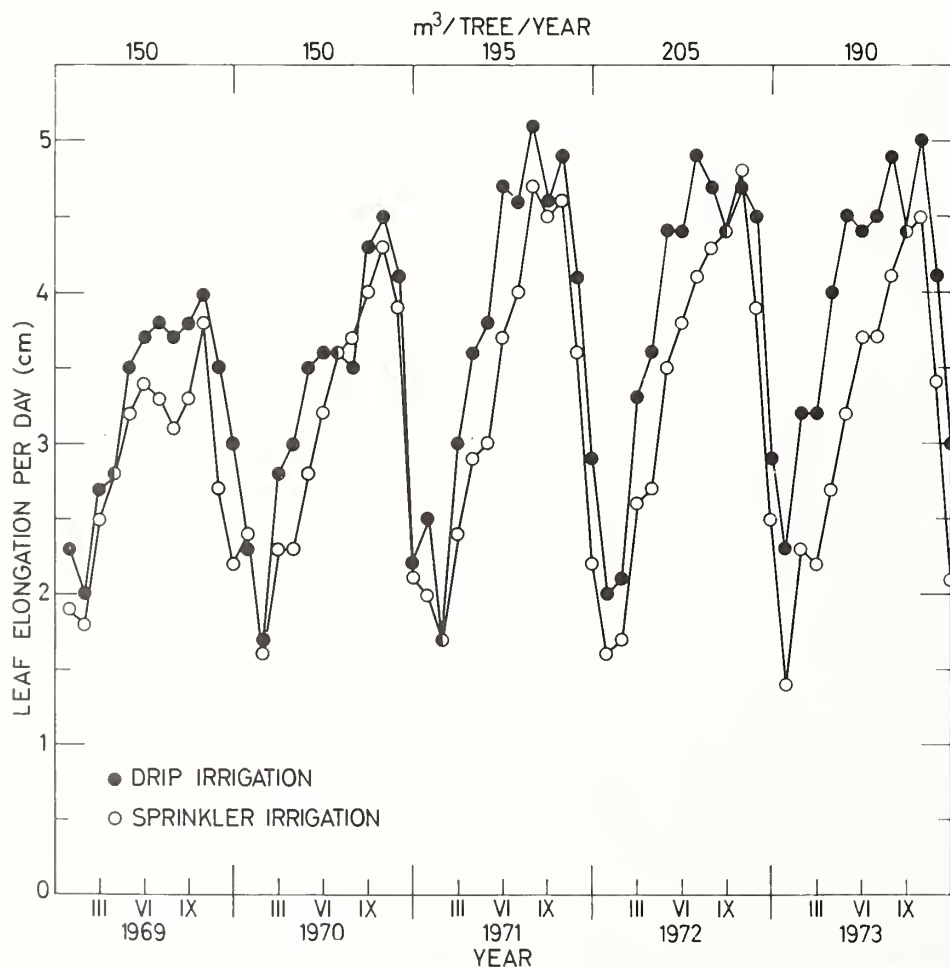


Fig. 1: Spike leaf elongation of trees irrigated by one dripping line or by sprinklers.

growth of the spike leaf was reflected in increased leaf production and more bunches. This was especially pronounced in the last 2 years, when the trees reached a steady state (Table 3). A higher water availability was reflected also in fruit size, which was bigger under drip irrigation (Table 4) than under sprinklers. Thus, it may be concluded that the drip irrigation method makes more economic use of water than sprinkler irrigation.

The data show that date palm trees can be grown when only a limited volume of soil between trees is wetted. An advantage was found to one line over two lines of drippers, although there was a significant difference in only some of the years. This difference may have been accidental and it would be worth while to test wetting even a smaller volume of soil than that in the trial described. The evidence for this possibility exists in one date palm garden ('En-Yavah'), where the trees have been irrigated by three drippers per tree for 5 years. In this garden the system is operated for 24 hours a day during the warm season (May-September), the watering is stopped before harvesting, to accelerate ripening, and then continuous irrigation is renewed for 1 week, alternating with a cut for 1 or 2 weeks during fall, winter and early spring. The trees are doing well and producing high yields. Adopting this method might save the investment costs of the system.

Although the aim of this trial was not to study the water consumption of a date palm tree, tentative conclusions can be drawn. Marked responses in growth and yield occurred when the quantity of water was raised from 150 m³ to 200 m³ per tree. A further increase in the water quantity, tried for a short period, brought about a rise in the water table. It seems, therefore, that the water consumption is about 200 m³/tree/

year. Considering that the average evaporation (from a U. S. Weather Bureau Class A pan) at this location is about 3500 mm/year, the ratio between irrigation water and evaporation is about 0.06 per tree. This factor seems to be minimal for good growth and yield with efficient distribution of water from drippers. The highly saline water table did not enable effective leaching of salts if higher amounts of irrigation water were used. Under conditions of better drainage and leaching, improved growth and yields might be anticipated.

Table 4 Annual average yield per tree and fruit weight of date palms irrigated by one dripper line (O), two dripper lines (T), or sprinklers (S)

Treatment	Yield/tree (kg)					Fruit weight (g)			
	1970	1971	1972	1973	Total	1970	1971	1972	1973
O	91.5	135.1	146.5	144.5	517.6	8.8	8.4	8.6	8.6
T	76.4	121.8	139.5	134.7	472.4	8.9	8.7	8.8	8.7
S	68.7	109.3	144.3	109.0	431.3	7.7	8.0	7.4	7.6
Significance ^a	OT/S	TO/ST	NS	OT/S		OT/S	OT/S	OT/S	OT/S

^a See footnote to Table 2.

Table 5. Annual percentage of fruits of different grades (A, B, Dry) produced on date palms irrigated by one dripper line (O), two dripper lines (T), or sprinklers (S)

Treatment ^a	Grade A (%)				Grade B (%)				Dry (%)			
	1970	1971	1972	1973	1970	1971	1972	1973	1970	1971	1972	1973
O	73	59	85	88	12	7	8	3	10	24	6	9
T	73	54	86	89	16	9	7	2	10	24	5	9
S	58	41	78	86	25	11	10	8	17	26	10	6
Significance ^b	OT/S	OT/S	OT/S	NS	OT/S	TO/ST	OT/S	OS/TO	OT/S	NS	OT/S	OT/S

^a Annual total may be less than 100%, since cullage is not included.

^b See footnote to Table 2.

Based on leaf analyses, the palms showed no significant variation in P content. Palms in other sandy soils of the Arava Valley apparently require supplementary amounts of K. Therefore, supplementary K was applied in two years. The rise in K content of the leaves found in spring 1972 may have been in response to the 1971 application of this element. Although the amount given was relatively high and the response was very small, it seems that K application to date palms needs further study, especially when a great amount of N fertilizer is added.

Leaf analysis of N showed a steady increase, which can be explained as a response to the N fertilization given, and to the possibility that trees had been partially deficient in N at the start of the experiment, in 1968.

In 1973 there was a reduction in yield (especially under sprinkler irrigation) although the number of bunches was greater than in the preceding year (Table 3). In other words, there were fewer fruits per bunch in 1973. This can be explained by one or both of the following possibilities: a) the size of the bunches was smaller (unpublished data of the author on 'Khadrawy' and 'Zahidi' cultivars showed that bunch size differs between years); and b) the re-

duction in fruit number per bunch was a result of a heavy June drop in 1973. If the latter possibility was the case, it might be attributed to the highest N level, which occurred in this year (Table 2).

In summing up the evidence, drip irrigation of mature Deglet Noor palms growing under marginal conditions of water, soil and atmospheric dryness has shown definite advantages over sprinkler irrigation during 5 years of the experiment. Drip irrigation supplies palms with water and nutrients at frequent intervals, permits minimal evaporation in comparison with sprinklers and permits slow rates of water application that help maintain a stable water table. Comparable drip irrigation systems introduced during the past 5 years to about 250 acres of commercial orchards in the Arava Valley are promoting excellent growth and yield in young and in bearing date palms. Some of these orchards are on gravelly soils and are irrigated with water containing 1000-2000 mg/l of chlorides. Thus, drip irrigation permits utilization of soils and water too poor in quality for most other crops.

The value of drip irrigation over other irrigation systems for date palms grown under optimal conditions of soil, water and climate, requires further study. However,

even under such circumstances it is reasonable to expect that drip irrigation may prove advantageous at least in establishment of young trees, by economizing on water use and by reducing weed growth on unneeded ground surfaces.

The physical quality of the water is an important consideration in drip irrigation systems. Sediment, algae and other sources of obstruction and malfunction in lines and drippers must be eliminated. This can be done with adequate filtering systems, such as that used for treated sewage effluent from the city of Elat, which is being used successfully in drip irrigation of date palms.

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XENIA AND METAXENIA STUDIES IN THE DATE PALM *PHOENIX DACTYLIFERA* L.

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ABSTRACT

Metaxenia and xenia effects induced in fruits and seeds of Deglet Noor date palm by pollen from five male clones and one inbred clone were compared. Size and shape of pericarp and seed, and the date of ripening were markedly affected. A striking metaxenic effect not reported previously was the dispersion of each character's measurements about its mean. Pollen from different clones produced almost identical effects as suggested by the character means, but the effects differed significantly as shown by standard deviation from the mean. Standard deviations of the metaxenic effects induced by the inbred clone tended to be smallest among the six male clones. Pollen of four male clones used on three female cultivars each produced consistent xenic and metaxenic effects on all of the females. Morphological studies of fruits derived from pollination of Deglet Noor and Med-jool females by each of two male clones were made at weekly intervals from pollination through the ninth week. The pollen had an observable effect only on abortive carpels. Early abortion was evident 1 week after pollination. The surviving carpel in flowers pollinated by Boyer 11 dominated the other two carpels which atrophied quickly. The surviving carpel that resulted from Fard 4 pollen did not dominate the abortive ones so quickly; the abortive carpels were still competing 9 weeks after pollination. The data support Swingle's original hypothesis that metaxenia is due to the influence of plant growth regulators produced directly or indirectly by pollen and strongly suggest that this effect is under genetic control. Data from the first part of the study imply that male clones superior to those in common use might be selected or inbred to improve the uniformity of fruit size, shape and date of ripening within bunches. However, if the metaxenia effect is genetically controlled, one-half of the metaxenic variability would be contributed by the male and one-half by the female. Thus, large improvements in fruit uniformity should not be expected only from selection or breeding of improved male clones.

Date Inst. Rep. 51:6

I. Influence of Pollen Parent on Mature Fruit Characters

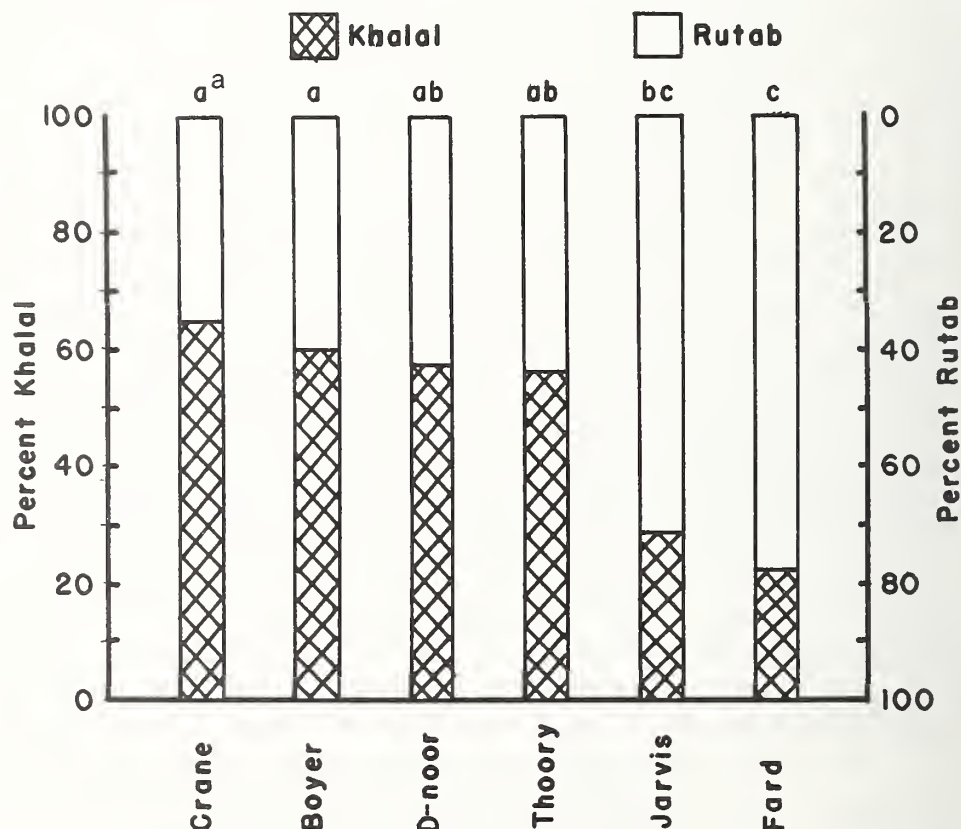
INTRODUCTION

The term "metaxenia" was first proposed by Swingle (24) to label a phenomenon observed in the fruit of the cultivated date palm (*Phoenix dactylifera* L.) He defined

metaxenia as a direct effect of pollen from a male clone on the morphology and other characters of seed and fruit tissues lying outside the embryo and endosperm. The date is dioecious, and the inflorescences on females are hand-pollinated with pollen from selected males. This term was coined to distinguish this phenomenon from the previously reported xenia effect of pollen source on the embryo and endosperm of corn and other plants due to direct gene action. Further, Swingle (24) suggested that metaxenia was due to hormones secreted (diffused) into the surrounding mother tissues by (from) the fertilized embryo and associated endosperm. Thus, the implication is that metaxenia is also genetically controlled, but indirectly. He predicted that it would be discovered to occur in other plants. The cause of metaxenia first suggested by Swingle is still the most plausible theory of its nature, but little research has been done to produce direct supporting evidence.

Swingle's prediction that metaxenia would be discovered in other plants was borne out. In fact, there is evidence that this phenomenon was observed in apple at a much earlier date by Nebel (9), but not documented by careful measurements until after Swingle's 1928 report (4, 5, 9, 11, 12). Some other crops in which metaxenia effects have been reported are: cotton (2), persimmon (20), pear (25), coconuts (13), chestnuts (8), peaches (23), and citrus (3).

The first experiments on effects of pollen on date fruit characteristics were begun in 1925 at the U. S. Date and Citrus Station, Indio, California, by R. W. Nixon (14, 15). These first papers presented data clearly establishing significant effects of pollen source on size and shape of seed and fruit and on time of ripening of 'Deglet Noor' and several other commercial date cultivars. Although Swingle's (24) and Nixon's (14) reports of a direct effect of pollen source on date fruit characteristics were the first



^a Means with letters in common do not differ significantly according to Duncan's (1) multiple range test.

Fig. 1. Effect of pollen source on the mean percentage of khalal and rutab stages of maturity in Deglet Noor fruits 21-23 weeks after pollination.

supported by experimental data, Popenoe reported this phenomenon in 1913 (21). Later studies by Nixon (16) covered experiments over several years with pollen from about 200 male clones (many were represented only by a single seedling palm) and showed that the Fard 4 and Mosque clones used in the original experiments defined approximately the extreme limits of the metaxenia effects produced by male clones of *P. dactylifera* on Deglet Noor. None tested produced smaller fruit and seed and earlier ripening than Fard 4, or larger fruit and seed and later ripening than Mosque clone pollen. Nixon (17) found that pollen of a number of other *Phoenix* species produced even more pronounced effects on fruit characters of Deglet Noor cultivar than were observed among *P. dactylifera* pollen sources. Nixon (18) showed that metaxenia effects were not greatly modified by the level of fruit thinning. In 1966, Lakhoua (6) reported studies on metaxenia in date palms in Tunisia.

Nixon's studies were based on measurements made on small samples of fruit, and most of the conclusions are drawn entirely from mean values obtained from such samples. No attention was given to the effect of pollen source on the nature of the frequency distribution curves of the fruit characters examined, although some frequency distribution data of individual fruit and seed measurements made on samples of from 20 to 100 fruits were presented without analysis or comment in his first paper (14).

The purpose of the present study, begun in 1970, was to obtain a more precise insight into the relation of pollen source to the dispersion and variability of date fruit characteristics. Comparative frequency distribution curves as well as mean values of several fruit measurements based on large samples were examined. The male clones studied included Fard 4, some commercial male clones, and an inbred Deglet Noor line resulting from three backcrosses (19). This latter clone was included to determine whether an inbred male line would produce less dispersion of some of the fruit characteristics measured.

To investigate the effect of pollen on a larger scale and to evaluate the uniformity of their metaxenic effects, more female cultivars were added in 1972.

MATERIALS AND METHODS (1970)

The seven male clones used in this study included Fard 4, the inbred clone Deglet Noor BC-3, Boyer 11, Thoory 20, Jarvis 1 and Crane A and B. Pollinations were carried out on seven 12-year-old Deglet Noor palms located in adjacent rows on the U. S. Date and Citrus Station, Indio, California.

The pollination techniques were similar to those developed by Nixon (14). Each dry pollen sample was sieved and introduced via a funnel into a 500 ml plastic wash bottle, slightly modified by cutting back the external end of its tube to provide a wider exit, and by fitting tube extensions on both sides of the original tube. These modifications were made to provide better flow of pollen and more control over the quantity used.

Blooming of the female palms occurred in three more or less distinct flushes at intervals of about 2 weeks; pollinations were made on March 13, 26, and April 7 of 1970. Two bunches from each flush on each

of the seven palms were prepared by opening them, cutting about 10 cm from the tips of the strands and removing the middle ones, leaving 44 strands on each bunch. Four pollination bags were used on each bunch, each covering 11 strands. Crane and three of the other six pollens were selected at random and used on each bunch; the Crane pollen was used twice as frequently as any other to provide a common reference on each bunch and to provide a further evaluation of experimental error. The variables in this experiment included: seven pollen sources (one of which was used twice), three pollination times, and two bunches per pollination time, which provided two sets of strands for each treatment.

Pollination was accomplished by making a pencil-sized hole near the closed end of the bag, introducing the tip of the tube and squeezing the plastic bottle, thus introducing pollen into the bag. The hole was sealed immediately after pollination to avoid any escape of pollen or contamination from other sources. The bags were removed after 4 to 5 weeks.

Observations were made on the progress of fruit set, color changes and softening. One of the palms was later dropped from the experiment because of its poor set of fruit. Also, one of the pollens, Barhee A-19, was dropped because its use gave consistently low fruit set.

Fruit in each treatment was harvested at the rutab (soft ripe) stage. In the laboratory a random sample of 25 fruits from each treatment was washed and left overnight to dry. The length and width of both fruit and seed were measured. The pericarp (flesh) was then dried for 3-4 days in a forced draft oven at 60° C and the dry weight recorded immediately after removal from the oven. The weight of fruit in the tables and figures refers to the dry weight of pericarp without the seed.

Terms used to describe the stages of fruit development are: kimri, the immature green stage from pollination to achievement of full size; khalal, immature fruit that has attained full size and has changed from green to a typical yellow to purple color, depending upon the variety; rutab, fruit that has passed the khalal stage and has softened and ripened.

RESULTS AND DISCUSSION

Differences in the start and progress of color development among fruits resulting from different pollen cultivars were observed in early experiments. Nixon (14) reported that pollens that hasten the change from green to the pre-ripe color cause early ripening of fruits as well.

In our experiments, a difference in color change from green to coral pink was observed, but actual recordings of pollen effects on earliness and lateness were not taken until the rutab stage of maturity. Figure 1 shows the mean percentage of rutab and khalal fruits in Deglet Noor for the period 21-23 weeks after pollination. Fruits from strands pollinated with Crane were 35% rutab, those pollinated with Fard 4 were 79%, while fruits from all other pollens were in between. Difference in maturity due to time of pollination was also significant. However, the early ripening of fruit from Fard 4 pollen was comparatively less affected than the late ripening of fruit from Crane pollen. A difference of 2 weeks in the time of pollination delayed the 50% rutab stage of Fard 4 one week, but delayed Crane more than 2 weeks.

The means of fruit and seed characters measured are shown in Table 1, together with their statistical indices.

Data for Crane A and Crane B represent the same pollen clone used as a standard of comparison on every bunch (see Methods and Materials). There was no significant difference between Crane A and Crane B in any of the measured characters for either fruits or seeds; in fact, in most of the measurements the means were almost the same. This indicates that the behavior of the pollen cultivars on each of the two bunches per palm selected for each treatment on each palm at each date was very similar, and that the experimental error between paired bunches was small.

Fard 4 and Crane formed the two limits for both the smaller and larger measurements, respectively; all others occupied an intermediate position (Table 1). Fruit breadth, however, showed no significant difference, possibly because the fruits were somewhat soft and it was hard to keep them in shape during harvest, transportation and handling.

Table 1. Influence of pollen clones on fruit and seed characters of Deglet Noor

Pollen clone	Fruit ^a			Seed ^a				
	Mean length (cm)	Mean width (cm)	Pericarp mean dry wt. g	Mean length (cm)	Mean width (cm)	Mean weight (g)	% of total fruit wt.	Fruit measured (no.) ^b
Crane A	4.25D	1.92	8.62C	2.60E	0.78C	0.90C	9.5C	450
Crane B	4.24CD	1.92	8.43C	2.59DE	0.78C	0.92C	9.8C	450
Boyer 11	4.17BC	1.92	7.90B	2.54C	0.74B	0.80B	9.2C	433
Deglet Noor BC3	4.10B	1.91	7.80B	2.55CD	0.74B	0.82B	9.5C	450
Thoory 20	4.10B	1.91	7.80B	2.43B	0.77C	0.82B	9.5C	450
Jarvis 1	4.11B	1.94	7.84B	2.46B	0.75B	0.79B	9.2	426
Fard 4	4.00A	1.94	7.37A	2.33A	0.72A	0.67A	8.3	450
Stat. Ind. ^c	°°	NS	°°	°°	°°	°°	ND	
C. V. % ^d	2	3	5	2	1	5		

^a Means with letters in common do not differ significantly according to Duncan's (1) multiple range test.

^b Number of fruits measured individually for each mean.

^c Statistical index: NS = no significant effect of pollen;

°° = significant effect at 0.01 level; ND = Not determined

^d Coefficient of variability, in percent.

The percentage of the mean seed weight in relation to the mean dry weight of the fruit shows that Fard 4 pollinated fruits had the lowest percentage of seed weight, 8.3%, while Crane fruits had the highest percentage, 9.6% (mean of A and B). This difference of 1.3 percentage points is of minor importance compared to the greater pericarp weight of Crane-pollinated fruits, which is the feature of primary commercial value.

Correlations between the dry weight of the flesh and the corresponding seed weight were calculated on samples of 54 fruits chosen randomly from the whole fruits of each pollen clone (Table 2). The inbred Deglet Noor BC-3 male produced the highest correlation and Boyer 11 produced no significant correlation, which suggests that both fruits and seeds produced from pollen of the inbred clone are more homogenous as a result of reduced heterozygosity in its effect on fruit characters than any of the other pollens used. The wide range of correlation level observed among pollens suggests that seed and pericarp sizes are not closely linked.

Table 3 shows an example of an apparent interaction between the date of pollination and pollen source on one of the seed characters under investigation. The effect of pollen source on seed weight was less pronounced on the April 17 date than earlier. Statistically significant interactions of this type were observed with four of the five characters measured. These interactions may have resulted mainly from variations in bunch size; the first flush usually produced the largest bunches and later flushes, progressively smaller ones. Because the number of strands per treatment was fixed at 11, the first bunches were probably thinned more heavily than later bunches and produced larger fruits. The number of fruits left on each strand may have affected fruit and seed size more strongly than the exact date of pollination. The relative positions of Crane A and B and Fard 4 pollens on seed weight remained the same as in Table 1.

Figures 2 and 3 show the frequency distribution of dry weight of fruit pericarps and seeds resulting from four pollen clones. Pericarp dry weights shown on the horizontal axis ranged from Class 1=5 to Class 16=12 g, with an interval of 0.5 g between the classes. Seed weights ranged from Class 1=0.155 g to Class 15=1.655 g, with an interval of 0.1g between classes. Chi-square tests indicated a significant difference among all the curves except between Crane A and Crane B, providing further proof of the validity of the experimental techniques used. The curves labeled Crane (Fig. 2, 3) are, therefore, means of Crane A and Crane B data. To avoid confusion, the curves for Jarvis 1 and Thoory 20 were not shown in Fig. 2 and 3, but both had shapes intermediate between Fard 4 and Crane.

Some of the frequency distribution curves (Fig. 2, 3) differ significantly in their mean values, but all differ significantly in their variances (standard error) about these means. The mean dry weight of pericarp produced by Deglet Noor BC-3 pollen differs significantly from that produced by Crane A and Fard 4, but does not differ significantly from Boyer 11 (Table 1). Nevertheless, Chi-square analyses show that all of these curves belong to different populations; that is, their standard errors differ significantly. Thus, although the means of

Table 2. Correlation between mean dry weights of seed and pericarp of Deglet Noor fruit

Statistical indices	Crane A	Crane B	Thoory 20	Pollen Clones			
				Deglet Noor BC3	Fard 4	Boyer 11	Jarvis 1
Coef. Corr.	0.294	0.556	0.470	0.572	0.393	0.168	0.319
Significance ^a	°	°°	°°	°°	°°	NS	°

^a NS = not significant; ° = significant at 0.05 level; °° = significant at 0.01 level.

Table 3 Interaction of date of pollination and pollen clone on seed weight of Deglet Noor fruit

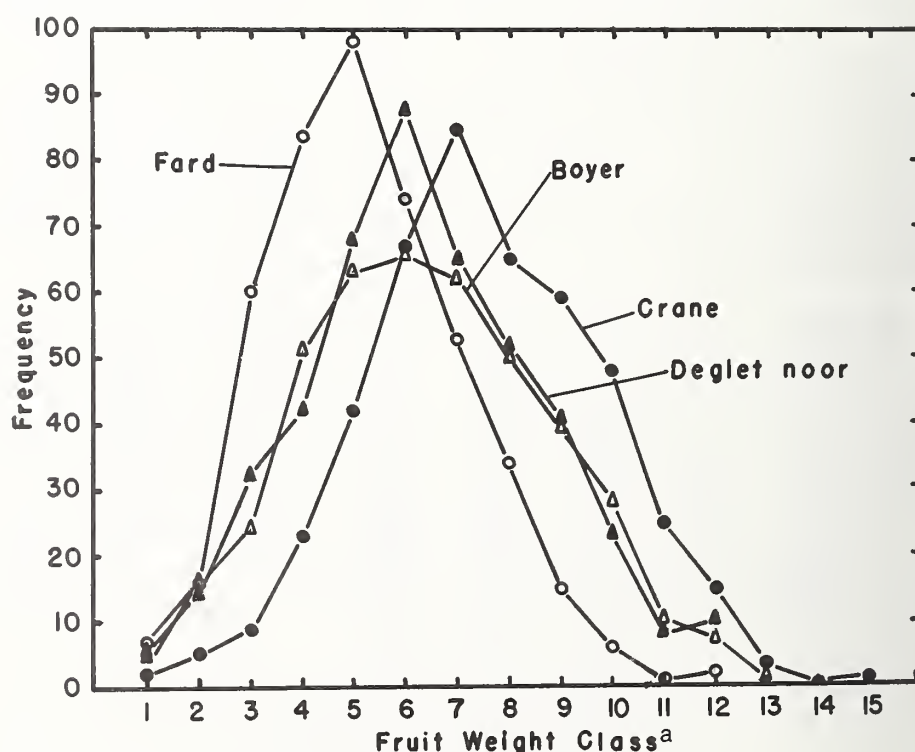
Date of pollination	Mean seed weight (g)						
	Crane A	Crane B	Boyer 11	Deglet Noor BC3	Thoory 20	Jarvis 1	Fard 4
March 13	0.92	1.00	0.86	0.82	0.88	0.82	0.68
March 26	0.94	0.96	0.79	0.80	0.83	0.80	0.70
April 7	0.84	0.81	0.76	0.74	0.74	0.75	0.64

Deglet Noor BC-3 and Boyer 11 do not differ significantly, the dispersions and skews of their frequency distribution curves are different. These two curves (Fig. 2) indicate that the dispersion (variance) of pericarp weight produced by Boyer 11 pollen is considerably greater than that for fruit pollinated with inbred Deglet Noor BC-3. Similarly, the shapes (variances) of the frequency distribution curves for length of fruits and length and breadth of seeds for each of the six pollen sources (data not presented) all differ significantly from each other, with the Deglet Noor BC-3 pollen showing the least dispersion about the mean for all characters measured except fruit breadth. From this it may be inferred that the dispersion of time of ripening of the inbred cultivar might be smaller, although this was not measured.

MATERIALS AND METHODS (1972)

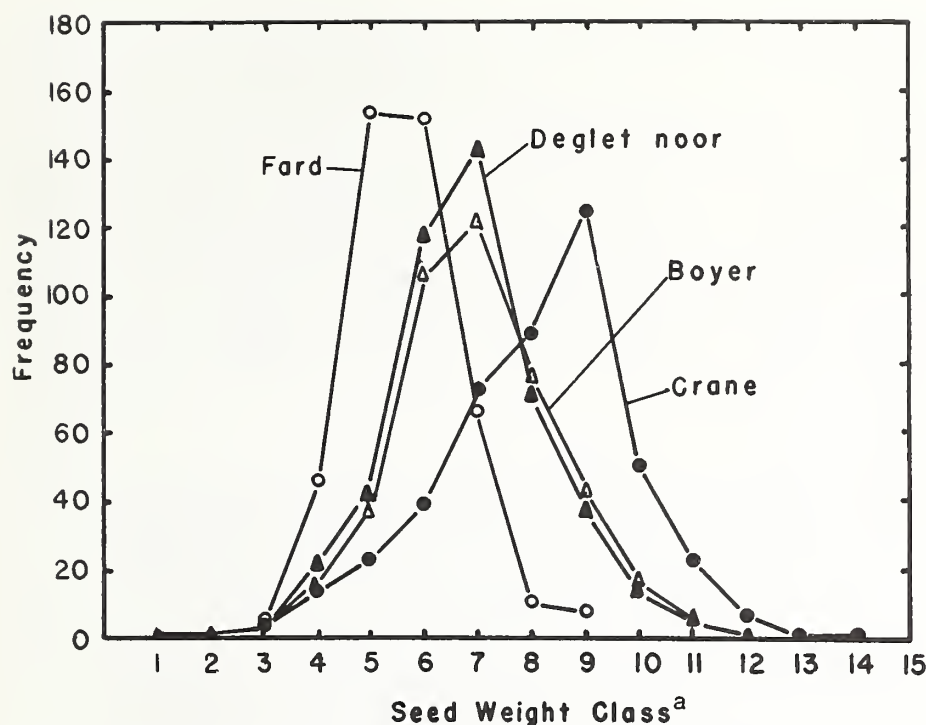
Besides collecting samples for morphological studies, this season's experiment was designed to measure xenial and metaxenial effects of four male clones on four female cultivars. The male clones used were Boyer 11, Barhee S (seedling), Jarvis 1 and Fard 4. The intention was to use the same males that had been used in 1970, but, unfortunately, some of them had been destroyed.

The four female cultivars were 'Medjool' and Deglet Noor, located at the U. S. Date and Citrus Station, Indio, and 'Halawy' and 'Barhee', located in the Laffin Date Garden at Thermal, about 12 miles south of Indio. Most of the fruit stalks of bunches of the Medjool broke, which curtailed fruit size data. The remaining bunches were used in the maturity progress study.



^a Class 1 = 5 g; classes progress at 0.5 g intervals to Class 15 = 12 g.

Fig. 2. Frequency distribution of dry weight of pericarp of Deglet Noor dates as influenced by the pollen clone used in pollination.



^a Class 1 = 0.155 g; classes progress at 0.1 g intervals to Class 15 = 1.655 g.

Fig. 3 Frequency distribution of seed weight of Deglet Noor dates in relation to the pollen clone used in pollination.

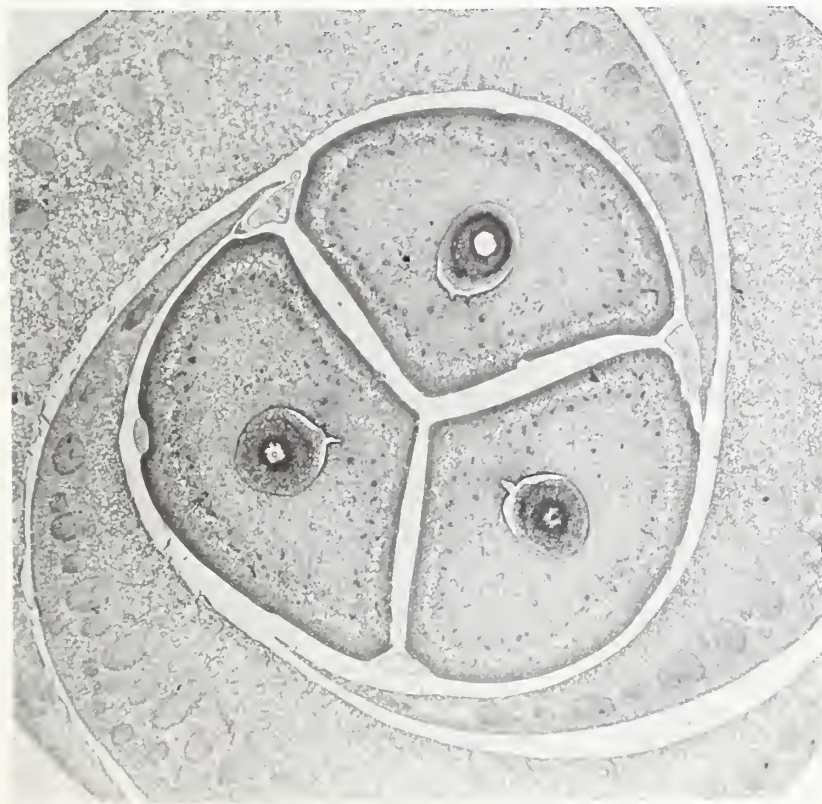


Fig. 4. Transverse section of a Deglet Noor flower showing the three equal carpels at pollination, 15 March 1972 (x 28).

Four bunches of about the same age on each of 4 uniform palms of each female cultivar were selected and prepared for pollination as in 1970. They were pollinated with pollen from the four male clones. The remaining bunches were pollinated commercially. The total number of bunches varied from one cultivar to another and also within a cultivar because of the differences in age and size of the palms. The mean number of bunches produced was: Halawy, 11; Barhee, 11; Deglet Noor, 9; and Medjool, 6.

Fruit from the treatments on Deglet Noor, Barhee and Halawy were sampled by harvesting four to seven strands at random from each bunch. Fruit and seed measurements were made in the laboratory where 20 fruits were selected randomly from the harvested fruit of each treatment. Pericarp was dried in a forced draft oven at 60° C until weight loss became less than 0.5% per day. Pericarp from the soft cultivars Halawy, Medjool and Barhee took 7 to 8 days to dry; Deglet Noor pericarp dried in 4 days.

RESULTS AND DISCUSSION

Fruit weights and measurements in the 1972 crop (Table 4) were generally smaller than those of the 1970 crop (Table 1). Part of this difference may be attributed to the averaging of measurements for the 3 female cultivars in 1972 and comparing these with measurements on one cultivar in 1970. Another reason might be that Boyer 11 pollen does not produce fruit and seed as large as that of Crane.

For the two fruit characters and the three seed characters under investigation (Table 4), there is a significant difference between the Boyer 11 and Fard 4 clones, while the Barhee S and Jarvis 1 clones are intermediate with a tendency to resemble Fard 4 in fruit characters and to resemble Boyer 11 in seed characters. The statistical indices for both fruit characters are identical, as might be expected because of the close relationship between fruit length and dry weight.

The last column in Table 4 gives the percentage ratio of seed weight to total fruit dry weight, as in Table 1. Although Boyer 11 showed significant differences from Fard 4 in both fruit dry weight and seed weight, the percentages of seed weight to the fruit dry weight probably are not significantly different; Barhee S and Jarvis 1 had higher percentages, the latter having the highest value. This relation should be given more emphasis in further evaluation of males because the pericarp is the only part of economic value of the date fruit.

None of the measured characters reported in Table 4 showed a significant interaction of the females with the males at the .01 level. Only one, seed weight, showed a slightly significant interaction at the .05 level. This lack of interaction indicates that any pollen clone which has a tendency to produce small fruit and seed sizes will do so on any female cultivar used. Conversely, any pollen clone which has a tendency to produce large fruit and seed sizes will do so on any female cultivar used. This result is in agreement with the findings of Nixon (16, 17).

Lack of interaction between the male clones and female cultivars used is shown further in Tables 5 and 6. These tables represent mean values for all the characters

being investigated. Variability among the means of the female cultivars for any single character is mainly a varietal character. This effect, though not mentioned before, has been observed for all the analyses of the results shown in Table 4. The Fard 4 clone approaches the lower limit in each character (Tables 5 and 6), and Boyer 11 clone approaches the upper limit.

The shorter length and lower dry weight of Deglet Noor fruit in comparison to the 1970 crop was due to a mite infestation which retarded fruit growth, but had only a minor effect on the seed size. The last column in Table 6 shows that Barhee had a lower percentage of seed weight than either Halawy or Deglet Noor which were similar. In each female cultivar, Jarvis 1 pollen produced the highest percentage of seed weight and Fard 4 produced the lowest, the other two males being intermediate. This is further evidence that the percentage of seed weight to total fruit weight is influenced by the pollen.

Frequency distribution data showed significant differences between the shapes of the curves representing the seed weights of Fard 4 and Boyer 11 pollinations. The difference in pericarp dry weights between Boyer 11 and Fard 4 is not large enough to be significant, in contrast with the 1970 results. In 1970, Crane pollen produced an even greater increase in pericarp weight than Boyer 11 (Table 1).

CONCLUSIONS

The data obtained in 1970 agree with those of several previous studies in showing large metaxenia effects of pollen sources on size, shape and weight of the pericarp and seed of date fruits, as well as on the time of ripening of the fruits. Furthermore, the data show that the pollen source may have even more striking effects on the dispersion of such characters about the mean; i.e., on the shape of their frequency distribution curves. The effect of pollen source on dispersion of characters has not been reported in previous studies.

Evaluation of the data in Fig 2 and 3 indicates that the pollen source exerts a significant influence on the frequency distribution of such characters as seed and pericarp weights, in a manner suggesting that metaxenia effects are under relatively simple genetic control.

In horticultural terms, the data indicate that a significant part of the spread in size, in time of ripening and in other characters of the fruit on a given bunch of dates is related to the heterozygosity of the pollen clone used. Furthermore, the data of 1970 imply that, by selection or inbreeding, a male clone might be obtained which would reduce the variability in such factors as fruit size, shape, seed size and time of ripening within bunches as compared with the commercial pollen clones now in general use.

The 1972 data provide information about uniformity of effect of male clones on female cultivars, suggesting that a pollen clone which has a tendency to produce small fruit and seed sizes may be expected to do so on any female cultivar and, conversely, a pollen clone which has a tendency to produce large fruit and seed sizes may be expected to do so on any female cultivar used.

The 1972 studies show that female cultivars vary in their seed—fruit weight ratios and that male clones affect this relation con-

siderably. In practice it might be desirable to consider this effect of male clones in future evaluation of pollen parents.

Assuming a growth regulator—genetic control theory, only half of the metaxenia variability observed would be contributed by the pollen parent, the other half being contributed by the female parent. Hence, a very large reduction in variability could not be expected by selection or breeding of males only. Moreover, the female cultivar effect on fruit variability may be influenced by environmental conditions, insects and diseases, time of pollination, bunch handling and nutrition, as well as by genetic factors.

II. Influence of Pollen Parent on the Early Developmental Morphology of Fruit

In most of the xenia and metaxenia studies of the date palm observations and evaluations of results that lend themselves to some kind of measurement have been of major concern. In the earlier studies, the majority of the effects of the phenomena were merely observed; only later were they investigated more closely. However, none of these investigations was intensive enough to indicate at what stage in fruit development could xenic and/or metaxenic effects be detected.

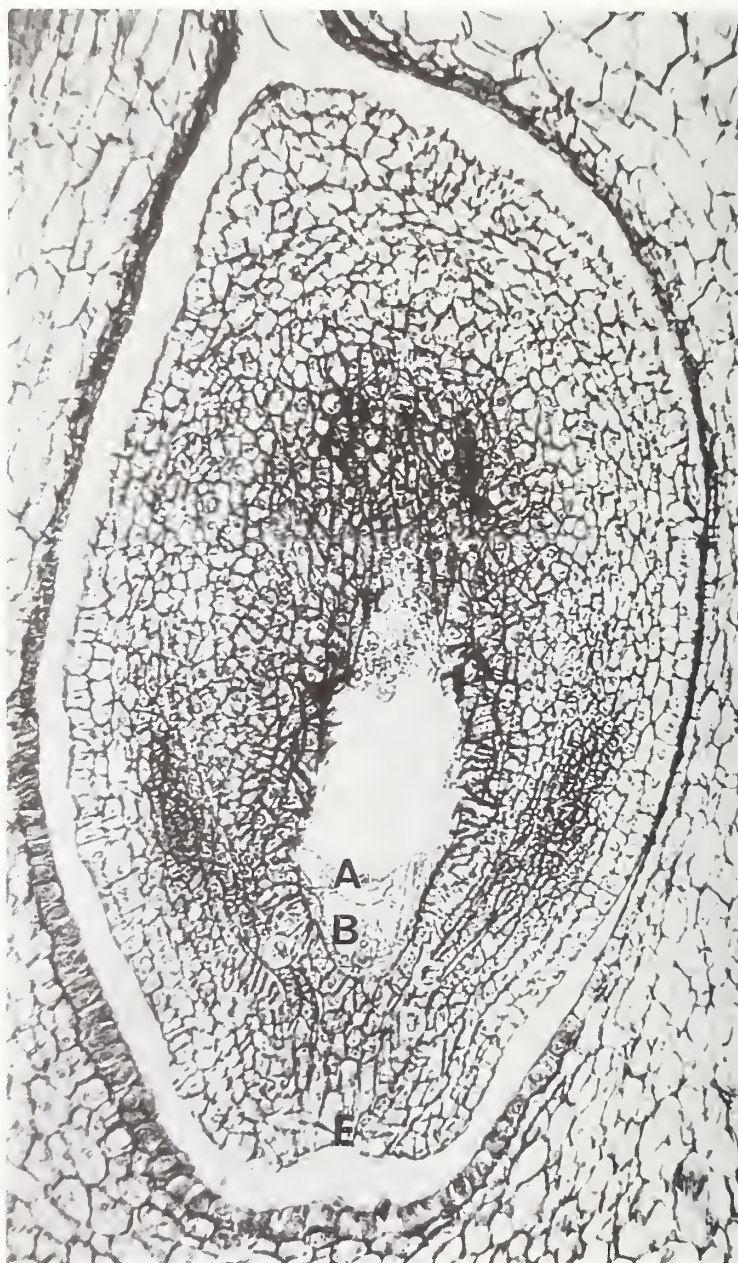


Fig. 5. Longitudinal section at pollination (15 March 1972) of Deglet Noor ovules showing a fully developed embryo sac with: A) polar nucleus; B) egg cell; C) inner integument; D) outer integument; E) micropyle (x 265).

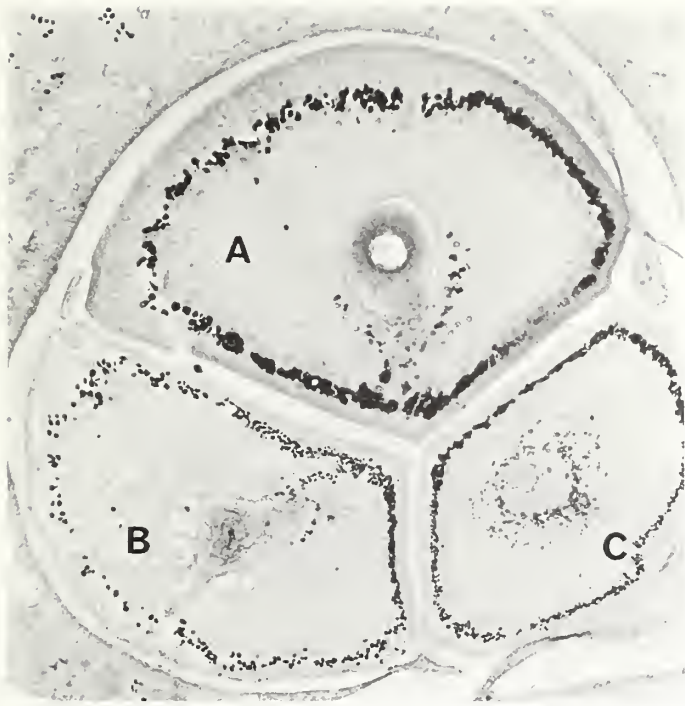


Fig. 6. Transverse section of a Deglet Noor flower 2 weeks after pollination by Moyer 11 pollen: A) one developing carpel with normal ovule and large tannin cells; B, C) two abortive carpels (x32).



Fig. 7. Transverse section of Medjool flower 2 weeks after pollination by Fard 4 pollen: A) one developing carpel; B, C) two abortive carpels, one with a well-developed ovule (x29).



Fig. 8. Transverse section of a Medjool flower 2 weeks after pollination by Boyer 11 pollen: A) one developing carpel; B, C) two abortive carpels (x30).



Fig. 9. Transverse section of a non-pollinated Deglet Noor flower 5 weeks after normal pollination time; A) one slowly-developing oval-shaped carpel with a collapsed ovule; B, C) two deteriorating abortive carpels (x26).

The morphological study reported here is an attempt to learn this for the date fruit by investigating early stages in the development of Deglet Noor and Medjool fruits produced by pollen from Boyer 11, a clone known to produce large-sized fruits, and Fard 4, a clone known to produce small-sized fruits. The study was restricted to the first 12 weeks after pollination because: a) a method was needed to evaluate a pollen clone quickly and efficiently as early as possible in the season, b) after the first 9 weeks the increase in fruit size results mainly from cell enlargement (7), and c) significant differences in size of mature seed and fruit were determined in the first part of this study.

MATERIALS AND METHODS

Samples used for this study were collected from Deglet Noor and Medjool palms growing at Indio, California. Pollination was carried out as in the other experiments. All inflorescences used on both palms were divided into equal halves, which were bagged separately. One bunch on each palm was bagged without pollination to serve as a control. Pollen from Boyer 11 and Fard 4 clones was applied to half-bunches so that each bunch had pollen from both clones.

Samples were taken at weekly intervals starting 1 week before pollination and continuing through fruit softening. Two to eight flowers or fruits were removed from alternate bunches and preserved in formalin-acetic acid-alcohol (FAA) or in Randolph's CRAF solution. After 24 hours the samples in CRAF solution were washed in running tap water and stored in 70% ethanol; those in FAA were kept in that solution. Portions from the first 13 weekly samples were prepared for microtome sectioning by dehydrating in ethanol and xylene followed by embedding in paraplast. Serial sections were stained with safranin O and fast green (FCF) for morphological study.

RESULTS AND DISCUSSION

The female date palm flower is trimerous with three separate carpels enclosed by a whorl of three overlapping petals and a whorl of three united sepals with only their

tips free. The carpels are sessile. They have styles about 0.5 mm long and stigmas barely showing outside the perianth. Six rudimentary stamens without anthers are always present.

The carpels are identical in shape, and all have the potential of becoming normal-sized fruits. However, after fertilization only one, or rarely two, attain full fruit size. If none of the three carpels is fertilized, all may slowly enlarge, as in Halawy, or only one or more may do so, as in Deglet Noor. In both cultivars, the result is a seedless, late-maturing, inferior fruit of no economic value.

The calyx was removed from fixed and sectioned samples to facilitate infiltration of solutions.

The petals were left in position to support the three carpels which are loosely attached to the floral axis. All sections studied were median or nearly so unless otherwise indicated. The floral and fruit development stages are discussed chronologically.

The pollination stage is illustrated by cross-sections of Deglet Noor flowers. The

three carpels are essentially identical in shape and size (Fig. 4). They have rounded abaxial sides and flat radial sides where they face one another. The measurement used for comparative purposes was the radial dimension across the middle of the carpels. At this stage, the average radial diameter of the carpels of both cultivars is less than 1.5 mm and that of the ovule (radial dimension) is less than 0.5 mm (Tables 7 and 8). Cells of the carpels are actively dividing and most of the characteristic cell layers are clearly identifiable, such as the uniseriate epidermis, the outer mesocarp, and two or three rows of large-sized cells which later are to become the conspicuous ring of tannin-containing cells. The inner mesocarp extends from the tannin cells inward to the uniseriate endocarp which surrounds the ovule. The three ovoid ovules, one per carpel, show active cell division, an indication that each has the potential of being fertilized and producing a seed.

The ovule has two integuments enclosing a disintegrating single-layered nucellus, which surrounds the mature embryo sac (Fig. 5).

The structure of the vascular system in

Table 4. Influence of four pollen clones on fruit and seed characters of three female date cultivars^a

Pollen clone	Fruit ^b		Seed ^b			% of total fruit weight
	Mean length (cm)	Pericarp mean dry wt. (g)	Mean length (cm)	Mean width (cm)	Mean weight (g)	
Boyer 11	3.64B	6.69B	2.27C	0.84B	0.98B	12.8
Barhee S	3.57AB	6.40AB	2.21BC	0.84B	0.97B	13.2
Jarvis 1	3.47A	5.99A	2.19AB	0.85B	0.99B	14.2
Fard 4	3.46A	6.00A	2.10A	0.79A	0.79A	11.6
Stat. Ind. ^c	**	**	**	**	**	ND
C. V.% ^d	4	11	4	4	9	—

^a Each value is a mean of the three female cultivars, Halawy, Deglet Noor and Barhee.

^b Means with letters in common do not differ significantly according to Duncan's (1) multiple range test.

^c Statistical index: ** = significant difference at 0.01 level; ND = not determined.

^d Coefficient of variability, in percent.

Table 5. Influence of four pollen clones on seed characters of three female date cultivars

Female cultivars	Pollen clone											
	Seed weight (g)				Seed length (cm)				Seed width (cm)			
	Fard 4	Jarvis 1	Barhee S	Boyer 11	Fard 4	Jarvis 1	Barhee S	Boyer 11	Fard 4	Jarvis 1	Barhee S	Boyer 11
Halawy	0.93	1.06	1.06	1.11	2.34	2.42	2.44	2.54	0.76	0.81	0.80	0.81
Deglet Noor	0.66	0.83	0.79	0.79	2.08	2.13	2.18	2.22	0.74	0.79	0.77	0.76
Barhee	0.78	1.07	1.06	1.03	1.88	2.03	2.03	2.04	0.86	0.95	0.94	0.96

Table 6. Influence of four pollen clones on fruit characters of three female date cultivars

Female cultivars	Pollen clone											
	Pericarp dry weight (g)				Fruit length (cm)				Seed weight as % of total fruit weight ^a			
	Fard 4	Jarvis 1	Barhee S	Boyer 11	Fard 4	Jarvis 1	Barhee S	Boyer 11	Fard 4	Jarvis 1	Barhee S	Boyer 11
Halawy	6.09	6.02	6.69	6.99	3.64	3.63	3.76	3.86	13.3	15.0	13.7	13.7
Deglet Noor	4.42	4.57	4.72	4.63	3.56	3.54	3.69	3.71	13.0	15.4	14.3	14.6
Barhee	7.51	7.38	7.79	8.47	3.18	3.23	3.26	3.36	9.4	12.7	12.0	10.8
												Mean

^a See Table 5.

Table 7. Mean width of pollinated and nonpollinated (control) fruits and seeds of Deglet Noor from pollination to the twelfth week; measurements expressed as (mm)^a

Sample Date, 1972	Nonpollinated		Pollinated March 15, 1972							
	Carpel	Ovule	Deglet Noor X Boyer 11				Deglet Noor X Fard 4			
			Carpel/fruit		Ovule/seed		Carpel/fruit		Ovule/seed	
			D ^b	A ^b	D	A	D	A	D	A
Pollination	1.319	0.382	1.319	1.319	0.382	0.382	1.319	1.319	0.382	0.382
3-22	1.395	0.437	1.736	1.321	0.481	0.368	1.852	1.522	0.434	0.438
3-28	1.535	0.452	2.453	1.020	0.558	0.344	2.577	1.043	0.562	0.353
4-4	1.692	0.531	3.402	—	0.705	—	3.057	—	0.744	—
4-11	3.139	0.713	5.239	—	1.019	—	4.392	—	0.877	—
4-18	4.108	0.870	5.371	—	1.058	—	5.479	—	1.027	—
4-25	4.402	0.798	6.305	—	1.271	—	6.278	—	1.244	—
5-2	6.122	0.586	7.285	—	1.513	—	7.078	—	1.540	—
5-9	6.140	0.250	7.967	—	1.890	—	8.371	—	1.622	—
5-16	6.591	—	9.278	—	2.325	—	9.350	—	2.500	—
5-23	8.171	—	10.683	—	3.083	—	10.817	—	3.417	—
5-30	9.788	—	12.267	—	4.660	—	12.883	—	4.317	—
6-6	10.525	—	13.440	—	5.740	—	12.933	—	5.255	—

^a Measurements from pollination time to the eighth week were taken from radial transverse sections.

^b D = developing; A = abortive.

the carpels appears to be identical with that of *P. reclinata* as described by Uhl and Moore (26). Each carpel has a main dorsal and two prominent ventral bundles (Fig. 4). Forty to fifty smaller bundles exist around the inner mesocarp adjacent to the tannin cells.

One Week After Pollination

DEGLET NOOR. An effect of fertilization was observed seven days after pollination in all the Deglet Noor flowers that were sectioned. Marked differences in size were observed between the surviving, fertilized carpel and the two abortive ones of the same flower. In non-pollinated flowers, the carpels increased slightly and were still alike in shape. The tannin cells of the fertilized carpels were larger than those of the non-pollinated control flowers, but both contained tannin.

Average measurements (Table 7) showed that while the three carpels of unpollinated control flowers increase uniformly in radial diameter by 76 mu, carpels fertilized by Boyer 11 pollen increased about 5 times as much

and those fertilized by Fard 4 pollen increased about 7 times. The aborted carpels of the pollinated flowers respond differently; the abortive carpels in flowers pollinated by Boyer 11 increased by only 2 mu, whereas those pollinated by Fard 4 increased by 203 mu. Thus, on the abortive carpels Boyer 11 pollen caused rapid and almost complete cessation of growth within 1 week, but Fard 4 did not.

Fertilized ovules increased in the reverse order of their carpels in response to the two pollens. Ovules fertilized by Boyer 11 pollen increased about twice as much as those fertilized by Fard 4 pollen (Table 7). In the abortive carpels, the average ovule was 14 mu less in radial diameter than in the flowers pollinated with Boyer 11 pollen, while in those pollinated with Fard 4 pollen radial diameter increased by an average of 56 mu, the same increment as that of the nonpollinated control.

In summary, during the first week, carpels fertilized by either Fard 4 or Boyer 11 pollen showed a rapid increase in size. With Fard 4 pollen, the abortive carpels

were growing and still competing, but with Boyer 11, the abortive carpels were immediately retarded and were not competing.

The carpels of the non-pollinated control flowers were still identical in size and the ovules appeared to be normal, although their rate of growth was somewhat less than that of the fertilized carpels pollinated 7 days earlier. The normal appearance of the ovules was consistent with the observation by Ream and Furr (22) that 7 days' delay in pollination after the spathes cracked open did not result in a decrease in fruit-set.

Figure 6 shows changes in the fertilized carpel with respect to increase in size, continuation of cell division, and rapid enlargement of tannin cells. Some cells along the abaxial side of the carpel were elongating and beginning to differentiate into stone cells that separate the epidermal and hypodermal layers from the mesocarp. The abortive carpels were comparatively small and had few or no cell divisions, thus yielding to the pressure exerted by the enlarging fertilized carpel.

Table 8. Mean width of pollinated and nonpollinated (control) fruits and seeds of Medjool from pollination to the twelfth week; measurements expressed as (mm)^a

Sample Date, 1972	Nonpollinated		Pollinated March 15, 1972							
	Carpel	Ovule	Medjool X Boyer 11				Medjool X Fard 4			
			Carpel/fruit		Ovule/seed		Carpel/fruit		Ovule/seed	
			D ^b	A ^b	D	A	D	A	D	A
Pollination	1.349	0.357	1.349	1.349	0.357	0.357	1.349	1.349	0.357	0.357
3-22	1.409	0.471	1.652	1.652	0.480	0.480	1.641	1.641	0.465	0.465
3-28	1.694	0.512	2.837	1.134	0.667	0.316	2.728	1.267	0.678	0.366
4-4	2.904	0.702	3.542	—	0.934	—	4.247	—	0.908	—
4-11	3.513	0.860	6.053	—	1.275	—	6.061	—	1.248	—
4-18	4.278	0.922	6.845	—	1.473	—	7.146	—	1.453	—
4-25	6.603	0.318	8.990	—	1.879	—	9.083	—	1.910	—
5-2	9.021	0.306	12.354	—	2.377	—	11.610	—	2.496	—
5-9	10.385	0.263	14.400	—	3.367	—	15.250	—	3.450	—
5-16	15.017	—	18.188	—	4.438	—	19.300	—	4.983	—
5-23	17.000	—	19.980	—	5.860	—	20.460	—	6.120	—
5-30	18.970	—	23.717	—	7.250	—	22.500	—	7.217	—
6-6	19.286	—	26.350	—	9.200	—	26.267	—	9.175	—

^a Measurements from pollination time to the eighth week were taken from radial transverse sections.

^b D = developing; A = abortive.

MEDJOOL. Unlike the Deglet Noor cultivar, no significant differences in size were observed among the carpels in Medjool flowers as a result of pollination 1 week previously with either pollen source (Table 8). The carpels of control flowers as well as those of the pollinated flowers remained similar in shape, but differed in size. In pollinated flowers, all three carpels increased in width 5 times as much as those of the non-pollinated control, and the ovules increased twice as much.

Two Weeks After Pollination

CONTROLS. In both female cultivars, the carpels of the controls increased in radial diameter by an average of only 140 μ during the second week without any noticeable change in appearance.

The ovules were well developed and had increased by 15 μ . According to Ream and Furr (22), these ovules could still be fertilized, but a 2 week delay resulted in about 15% reduction in fruit set in comparison with those pollinated immediately after the spathe opened.

POLLINATED FLOWERS. The fertilized carpels of both female cultivars (Fig. 7) continued enlarging at a rate 5 to 6 times that of the unpollinated control, while their ovules increased by 5 to 10 times that of the control. The stone cells in the mesocarp were approaching their maximum size. The abortive carpels of the pollinated flowers were still visible in all samples. Figures 7 and 8 represent Medjool flowers pollinated by Fard 4 and Boyer 11 pollen, respectively. At this stage some of the aborting carpels of the Fard 4-pollinated flowers had well-developed ovules (Fig. 7), while in most of the aborting carpels of the Boyer 11-pollinated flowers (Fig. 8) the ovules were collapsing. Continued ovule growth might have resulted from fertilization of all of the ovules, but only one carpel dominated in each flower. This delayed suppression of the abortive ovules was observed more frequently in Fard 4-pollinated flowers, and might be disadvantageous to the developing carpel.

Three Weeks After Pollination

With the unpollinated controls of Deglet Noor and Medjool, both the carpels and the ovules show a slow enlarging trend. In sectioned samples, one carpel (rarely two) dominated.

With pollinated carpels, both cultivars were approaching their final cylindrical shape. The hypodermal layer was filled with localized tannin. Remnants of the collapsed carpels could still be seen. The thickening stone cell walls were made conspicuous by their uptake of safranin, especially in the cells around the abaxial side of the carpel.

Fourth Week Through Ninth Week

CONTROLS. Scattered air spaces in the mesocarp of the dominant carpels (Fig. 9) indicated that cell divisions were less frequent and that the rate of enlargement of the ovary was lessened. The dominating carpel was still oval in shape, while the other two carpels had almost stopped enlarging, but were visible.

The ovules of all carpels, including the dominant ones, were collapsing and showed few signs of cell division. Thus, by the ninth

week it became difficult to obtain measurements. The non-pollinated flowers finally produced parthenocarpic fruits of poor quality.

FERTILIZED CARPELS. Progressive enlargement of the pericarp continued until fruit maturity. Major morphological changes were observed in the developing seeds, particularly in the endosperm. Beginning with fertilization and lasting until the fourth and fifth weeks, the volume of the embryo sac increased greatly in size and the endosperm was in a free nuclear condition. While very little localized tannin was seen in the 4- and 5-week-old ovules, it was concentrated in three rows of cells which form a prominent band in the integument of the 6-week-old ovules. In the sixth week the endosperm was forming a uniseriate layer next to the nucellus. Samples taken after 8 weeks (Fig. 10) showed continued cell formation in the endosperm. Typically, there were three layers of cells, the middle layer being composed of much larger and radially enlarged cells with prominent vacuolation and absence of tannin. The vascular system of the developing seed is evident in the integumentary tissue.

During the ninth and tenth weeks the endosperm continued to increase rapidly (Figs. 11 and 12). Figure 11 shows that most of the increase in size of the endosperm resulted from cell division. The endosperm as a whole was taking its characteristic mature crescent shape with the two ends of the crescent engulfing the remaining ovular tissue in which the vascular system is located. The inner integument had shrunk

to two rows of cells. The inner, but not the outer layer, had tannin localized in its cells. The outer integument was composed of several cell layers, of which the outer two and the inner two did not have tannin, but the seven or eight layers of comparatively larger cells in between contain much tannin and form a continuous band in the seed.

Besides the continuous increase in size of the endosperm, secondary wall thickening was taking place in the cells (Fig. 12). The nucellus and part of the integument were compressed by enlargement of the endosperm. The remaining integumentary layers had somewhat less tannin per cell and they became tangentially elongated as a result of the pressure exerted by the expanding endosperm.

Weekly sampling for sectioning was terminated when, at the end of the tenth week, the endosperm cell walls had become too thick and hard to serial section by the paraffin method.

Morphological comparisons made for the stage from the fourth through the ninth week did not reveal any difference in size or shape between the Boyer 11-pollinated fruits and the Fard 4-pollinated ones on either female cultivar. Furthermore, statistical analyses of fruit and ovule data (Tables 7, 8) showed that while fertilization had a significant effect on fruit size as compared with non-fertilization (control), there was no significant difference in size of carpels and ovules between fruits resulting from fertilization by the two male clones on both female cultivars.



Fig. 10. Transverse section of a Medjool ovule 8 weeks after pollination by Boyer 11 pollen, with three layers of endosperm cells, localized tannin and vascular system (x39).



Fig. 11. Transverse section of a Medjool ovule 9 weeks after pollination by Boyer 11 pollen showing cell formation in all of the endosperm and an increase in its volume (x29).



Fig. 12. Transverse section of a Medjool ovule 10 weeks after pollination by Boyer 11 pollen showing the expansion of the endosperm and compression of the integuments (x22).

CONCLUSIONS

Weekly measurements of carpels and developing seeds of Deglet Noor and Medjool fruits fertilized by Boyer 11 and Fard 4 pollen starting at pollination and continuing through the ninth week failed to establish significant differences within cultivars in size resulting from these two pollen sources during this period of fruit development. However, the two pollens showed a different effect on the aborting carpels as early as 1 week after pollination. Where Boyer 11 pollen was used, the surviving carpel continued to grow and develop, but the remaining two carpels in each flower stopped growing and atrophied within weeks. On the other hand, where Fard 4 pollen was used, all three carpels on each flower grew during the first week after pollination, the rate of growth of the surviving carpel being greater than that of the two carpels which were to abort. Nevertheless, the aborted carpels had grown more during the first week after pollination than did the carpels of the non-pollinated flowers during the same time.

The difference in the fruit and seed size and the time of ripening (about 24 weeks after pollination) observed in this part as well as in the previous part of the study is expressed morphologically at a stage after the ninth week in fruit development.

These studies of comparative early development of the carpels and ovules in relation to pollen source, like the studies of the gross morphology of mature fruit, tend to support Swingle's (24) original hypothesis that metaxenia is due to the influence of plant growth regulators produced, directly or indirectly, by the pollen, and also with the evidence suggesting that this effect is under genetic control.

SUMMARY

Metaxenia and xenia effects induced in fruits and seeds of the date palm cultivar Deglet Noor by pollens from five common male clones and one inbred clone were compared in the 1970 crop season. As reported in previous studies, the data show large metaxenia effects on size and shape of pericarp and seed, and on date of ripening, as revealed by the mean values of the several characters measured. A striking metaxenia effect not reported previously, however, is the dispersion of each character's measurements about its mean. Analysis of the data shows that the pollens from different clones may produce almost identical effects, as suggested by the character means, but that the effects differ significantly, as revealed by the standard deviation from the mean. The standard deviations of the metaxenia effects induced by the inbred cultivar tended to be smallest among the six male clones. Data obtained in the 1972 season, when four male clones and three female cultivars were used, show the consistency of the male clones in their xenic and metaxenic effects on all of the female cultivars.

The major part of the study in 1972 was devoted to the developmental morphology of fruits arising from pollination by two male clones. Observations made on sectioned samples taken at weekly intervals, starting with pollination and extending through the ninth week, showed a significant effect only on the aborting carpels. This occurred as early as one week after pollination. The surviving carpels resulting from Boyer 11

pollen dominated the other two which atrophied within weeks. Those resulting from Fard 4 pollen, though growing at a faster rate, did not so quickly dominate the ones which were to abort; thus, the aborting carpels were still competing 9 weeks after pollination to the disadvantage of the resultant fruits.

All data obtained in this study tend to support Swingle's original hypothesis that metaxenia is due to the influence of plant growth regulators produced, directly or indirectly, by the pollen. Moreover, the present data strongly suggest that this effect is under genetic control.

In horticultural terms, the data from the first part of this study imply that male cultivars might be obtained by selection or inbreeding which would improve the uniformity of such factors as fruit size, shape and date of ripening within bunches as compared to the male cultivars now in common use. However, if it is assumed that the metaxenia effect is genetically controlled, only half of the metaxenia variability would be contributed by the pollen source, and very large improvements in fruit uniformity could not be expected by male selection or breeding only.

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SUPPLY OUTLOOK FOR SEASONAL AGRICULTURAL LABOR IN CALIFORNIA

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ABSTRACT

Seasonal farm labor in California is discussed in relation to past, present and future availability and requirements for such labor. Extensive employment statistics for the period 1963-1973 cover domestic and foreign farm workers. An example of an intelligently planned, long-term management program for seasonal farm labor, which has been in operation in the citrus industry since 1965, is outlined.

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INTRODUCTION

This year, more than in the past two or three, farm employers feel uncertain about the supply of farm labor, particularly the supply of labor to do seasonal jobs. Further, the farm labor demand-supply situation may become more uncertain in 1975 and 1976 as increased acreages of grapes, nuts and fruit come into bearing and the acreage of vegetables increases.

In 1972 no major shortages were experienced in the State; however, there were some local shortages. The Department of Human Resources Development reported that "Although surplus labor conditions were not as extensive as in 1971, the supply of labor was usually greater than demand" (2). No major shortages of labor occurred in 1973, but local shortages were more numerous. For several commodities, the labor for harvest was in quite short supply.

In this discussion I will focus mainly on some aspects of labor supply and one particular approach to farm labor supply problems. To put this discussion into perspective, I will first review very briefly trends in employment.

EMPLOYMENT

Employment data are estimates of the number of workers employed at any given time or estimates of the average number of workers employed during a given period of time, such as a month or a year. The employment data we have for California agriculture are the Employment Development Department's estimate of the number of people employed on farms at the middle of the month (3). Such data do not reveal labor shortages farmers experience or the unemployment workers experience, but do help us understand the changing situation (Table 1).

Average annual employment of farmer and unpaid family workers and seasonal workers has tended to decline, while the employment of regular workers has tended to increase slightly.

The employment of seasonal workers has tended to decline on an annual average basis. But if we examine the employment

levels during the month of peak employment, (3) we see that the average number of seasonal workers employed during the month of peak employment (September) has not declined much since 1965 (Table 2).

By the middle of the 1960's, peak employment of seasonal workers declined to about 180,000. In recent years, except for 1972, peak seasonal employment has tended to fluctuate around 180,000 (3). Apparently over the course of the year employment during the peak months has tended to become higher and employment during the low months, lower (Table 3).

If we compare 1973 with 1966 it appears that employment during the high months has remained at about the same level, while employment during the low months has declined slightly. It remains to be seen how the annual pattern changes as the bearing acreage of grapes, fruits, nuts, and vegetables increases. If mechanical harvesting of these crops increases, we may see an increase in employment during the low months without a corresponding increase in the peak months.

These data reflect what every fruit and vegetable producer knows: seasonal workers

are very important to California agriculture, and meeting the seasonal labor needs each year represents the mobilization of manpower on a large scale. The importance of seasonal labor may increase in the next several years as agriculture expands.

SUPPLY OUTLOOK

Attempting to gain an impression of the seasonal labor supply outlook for even one season ahead is extremely difficult. On one hand the available data are not ever as complete as one would like. On the other hand it is hazardous to forecast the future by examining the past. But there are no alternatives known to me. In this discussion I am mainly concerned with the seasonal hired farm labor. The two types of hired farm workers, regular and seasonal, are not separately and distinct on every farm, but they are distinct enough to discuss separately. Further, the Department of Employment Development uses the distinction in assembling and publishing employment data.

It was noted previously that during the month of peak employment in 1973 in California about 183,000 seasonal farm workers were employed. Of this number 132,000 approximately were local workers, about 29,-

Table 1. Annual monthly average employment of various categories of workers on California farms, 1963-1973 (2)

Year	Total	Farmers and unpaid family	Hired domestic			Contract foreign	Total seasonal
			Total	Regular	Seasonal		
1963	318,400	93,900	196,500	93,500	103,000	28,000	131,000
1964	316,100	92,500	195,600	90,900	104,700	28,000	132,700
1965	302,600	90,600	209,200	90,300	118,900	2,800	121,700
1966	302,100	88,800	212,100	90,800	121,300	1,200	122,500
1967	292,400	84,900	207,000	92,200	114,800	500	115,300
1968	294,400	82,500	211,900	93,200	118,700	0	118,700
1969	291,100	80,600	210,500	94,400	116,100	0	116,100
1970	289,100	78,600	210,500	96,800	113,700	0	113,700
1971	287,100	76,700	210,400	96,100	114,300	0	114,300
1972	279,300	74,500	204,800	95,600	109,200	0	109,200
1973	282,058	72,266	209,791	96,158	113,633	0	113,633

Table 2. Average employment of various categories of workers on California farms in September, 1963-1973 (3)

Year	Total	Farmers and unpaid family	Total	Hired domestic Regular	Seasonal	Contract foreign	Total seasonal
1963	404,100	95,900	254,200	95,300	158,900	54,000	212,900
1964	411,800	94,400	253,500	92,300	161,200	63,900	225,100
1965	361,900	91,600	258,900	91,900	167,000	11,400	178,400
1966	362,200	89,100	265,300	92,300	173,000	7,800	180,800
1967	373,600	87,400	286,200	95,300	190,900	0	190,900
1968	357,900	85,000	272,900	96,000	176,900	0	176,900
1969	369,500	83,500	286,000	98,400	187,600	0	187,600
1970	360,800	80,600	280,200	99,600	180,600	0	180,600
1971	361,800	79,500	282,300	99,400	182,900	0	182,900
1972 ^a	332,800	77,700	255,100	100,000	155,100	0	155,100
1973	360,000	76,100	283,900	100,900	183,000	0	183,000

^a August was the peak month.

Table 3. Midmonth estimates of employment of seasonal workers on California farms in selected years (3)

	1966	1971	1972	1973
	Number of Workers			
Jan.	95,400	81,600	81,900	78,000
Feb.	89,600	77,300	77,600	62,300
Mar.	77,950	75,100	74,100	67,700
Apr.	94,950	93,800	93,000	83,400
May	146,750	123,900	135,000	127,300
June	152,300	148,200	143,500	149,500
July	140,000	138,000	132,500	145,700
Aug.	163,500	155,200	155,100	160,800
Sept.	180,800	182,900	152,500	183,000
Oct.	150,400	130,600	121,900	143,900
Nov.	91,500	82,900	66,100	75,900
Dec.	86,900	83,300	80,200	86,100
Annual				
Avg.	122,500	114,200	109,200	113,600

000 nonlocal but from areas within the State, and about 21,000 from areas outside of the State (6). This pattern of predominant importance of local labor in seasonal agricultural employment also prevails when we examine the pattern at the county level. In Fresno County, for example, during September, 1973 employment of seasonal workers was slightly more than 51,000. Of these, 34,000 were local and 17,000 nonlocal; 9,000 nonlocal workers came from areas within the State and approximately 8,000 from areas outside the State. In Riverside County in 1973, 7,110 seasonal workers were employed during June, the month of highest employment. Of these 5,040 were local, 1,250 were nonlocal from within California, and 820 were from outside the State. Among counties there is some variation in the proportion of labor supply that is of local origin, but in no county are the seasonal workers predominantly nonlocal. These data do not suggest that nonlocal labor is unimportant. One-third of the seasonal labor supply is a very important part of the total.

These data do suggest a question: could additional seasonal labor be obtained from local sources? The reason for raising this question becomes more evident when we look at the data with respect to number of individuals who work in California agriculture. For example, in the third quarter of 1972, 424,000 different workers worked in California agriculture. If we array these workers by numbers of employers each had during the quarter we obtain the distribution shown in Table 4 (4).

It was noted previously that approximately 96,000 regular workers are employed in California agriculture. Thus the first category, workers who had one employer, probably includes 96,000 regular workers. The average earnings figure also includes the earnings of these regular workers. This suggests that the 212,000 workers averaged much less than \$638 (\$213 per month) in the third quarter. It is also reasonable to conclude that these individuals were less than fully employed in the third quarter. The data do not reveal anything about the days and hours of work or proficiency of workers. We have only number of workers, number of employers, and earnings. It seems that for seasonal farm work, where piece rates commonly prevail, \$213 or less per month does not suggest relatively full employment. Some unknown proportion of the 395,000 individuals in categories 1, 2 and 3 (employers) reside in the local area in which they work. Given the low level of

agricultural earnings reported, a large proportion of these individuals worked in agriculture for only a limited time during the third quarter of 1972. For example, the 12,896 workers who worked for four or more employers in the third quarter averaged \$832 for the quarter, or approximately \$278 a month. They appeared to have been more fully employed than those who worked for one employer. Those who worked for 10 or more employers averaged over \$400 a month. We cannot detect from the data the extent to which limited employment was a choice made by the worker. We do not get any clues as to how many would have preferred more work but were unable to obtain it. There are many other questions one might ask, but the main point I want to make is that apparently a very large proportion of those who take farm employment realize a relatively short period of employment. We do not know how much more employment such workers would take if offered and what terms of employment would be required to induce such individuals to work for longer periods.

There is an additional observation to be noted about these data. Employment figures presented previously give us an indication of the dimensions of manpower mobilization that takes place each year on California farms. The figures relate to only one quarter. We could construct a tabulation like this for each of the four quarters of the year. The numbers in the first, second and fourth quarters would be somewhat smaller; in no quarter of 1972 would the number of workers fall below 225,000. Since we can be reasonably confident in assuming that the vast majority of the 96,000 individuals who are regular farm workers are employed the year-round, we can say that more than 300,000 individuals are employed temporarily at various times in California agriculture in the course of the year.

These data suggest another question: what is happening to the number of people who take employment on California farms?

Table 4. Number of workers, number of employers workers had, and average earnings per worker in the third quarter, 1972 (4)^a

Number of workers	Number of employers worked for	Average earnings per worker
308,989	1	\$ 638
61,226	2	707
25,354	3	766
12,896	4	832
6,887	5	861
3,861	6	940
2,215	7	1,023
1,239	8	1,097
763	9	1,122
1,114	10 or more	1,239
Total:		
424,544		

^a The terms "workers," "employers," and "earnings" are not exactly precise. Two or more workers who use the same Social Security number are counted as one worker. A worker who is an employee of a labor contractor and works on several farms is counted as having one employer. The earnings refer only to earnings in California. Farm workers who are covered by unemployment insurance are not included in this tabulation.

Table 5. Total number of workers in the second and third quarters, 1965-1972 (5)

Year	Total number of workers Second quarter	Third quarter
1965	436,526	509,390
1966	422,182	488,532
1967	373,039	459,008
1968	400,297	469,164
1969	403,551	467,068
1970	383,832	448,181
1971	367,586	429,330
1972	385,891	424,544
1973	404,958	—

Since the third quarter is the period of highest employment (5), the trend in numbers of workers who worked in the third quarter is of interest (Table 5. This tabulation includes both regular and temporary workers. If we subtract from the total employment in the third quarter of 1965 approximately 92,000 regular workers and, if we subtract 100,000 regular workers in 1972, we can consider the remaining workers to be temporary workers. Given this crude adjustment, we can say that in the third quarter the number of individuals who took temporary work in the third quarter declined from 417,000 in 1965 to 324,000 in 1972. This is a decline of about 22 percent. It appears that there was a decline in number of people who did farm work during a period when the employment of seasonal workers during the month of peak employment tended to increase slightly each year. In making this comment about increasing peak employment we ignore 1972 and include 1973. Weather conditions that prevailed in 1972 made that year somewhat atypical. If we look at the number of individuals who worked in California agriculture in the second quarter, we can see that the evidence of decline in numbers of individuals who work in agriculture is not overwhelming.

While the total number of individuals who worked for wages on California farms appears to be declining, the role of the illegal immigrant, mainly from Mexico, appears to be expanding. Successive annual reports of the Immigration and Naturalization Service indicate that the number of illegal immigrants from Mexico is increasing. From 1968 to 1972 the numbers of deportable Mexican aliens located were as follows (10):

Year	Number
1968	151,705
1969	201,636
1970	277,377
1971	348,178
1972	430,213

The bulk of these deportable aliens were located before they were able to obtain employment in any occupation. In 1972 about 84,000 known illegal immigrants were working in U.S. agriculture. This is slightly more than double the number so located five years earlier.

It is difficult to estimate what proportion of the seasonal farm labor supply is supplied by illegal immigrants. No data are available on the amount of farm work done by illegal immigrants. Perhaps equally important, it is not known how many illegal immigrants have not been located.

One writer has reported that estimates of the total number of illegal immigrants in the United States range up to five million. The same writer reports that the annual incomes lost to displaced U. S. workers have been estimated at \$10.4 billion (1). The increase in illegal immigrants and the discovery of some irregularities in the operation of the Immigration and Naturalization Service have given rise to an intensive effort to eliminate these irregularities, to stop the flow of illegal immigrants to this country and to deport illegal immigrants. It is reasonable to expect fewer illegal immigrants to be employed in California agriculture in 1974 than in 1973 and 1972.

An important part of the farm labor force in California is the immigrant who enters the United States with an immigration visa which permits him to live and work here permanently. In accordance with the requirements of the Immigration and Nationality Act, aliens must file address report cards with the INS in January each year. In 1972, 4,227,219 filed cards. Of these 87 percent registered as permanent residents, the remaining claimed temporary status. The largest number of aliens reporting were of Mexican nationality. Eighty-one percent of the 735,018 permanent-resident Mexicans resided in the two border states of California and Texas (11). It is known that a substantial number of these Mexican immigrants pursue agricultural occupations, but the most recent survey was made in 1965, which indicates that of the 631,000 Mexicans filing address cards, about 5.5 percent or 34,700 listed their occupations as farm laborers and foremen (8). Because the address cards are filed in January, the number reporting agricultural work is probably somewhat less than it might have been had the cards been filed in summer or fall.

Several other factors should be noted that bear on the changing farm labor supply situation. The first of these is the increasing tendency for farm wage workers to be made up of people who are not in the labor force most of the year. In the period 1947-49 to 1971-72 the proportion of U. S. farm wage workers who were not in the labor market most of the year increased from slightly more than 20 percent in 1947-49 to about 40 percent in 1971-72 (7). The bulk of these individuals who are not in the labor force most of the year are housewives and students. In 1972, of the 2.8 million individuals who worked for wages in agriculture, 1.4 million were not in the labor force most of the year. Of these, 0.3 million were housewives and 1.1 million were students. This is a very interesting and important trend. Insofar as housewives and students are employed in seasonal farm work we are employing a labor supply for seasonal work that for the most part does not want year-round employment. In doing so we avoid the social and economic problems frequently associated with seasonal farm work. In California the employment of youth is important, but such workers are used to a lesser degree than is the case nationally. In recent years in California agriculture about 5 percent of the hired year-round workers and about 11 percent of the temporary workers during the peak period were youth (2).

These observations on the changing labor supply situation and the labor supply prospects do not constitute an adequate analysis of this important problem. I have merely tried to describe some elements that bear on the prospects for seasonal labor.

There is one additional comment about the labor supply that I should mention. This is an item that appears in the 1972 *Manpower Report of the President*, p. 50. That report, which represents the official position of the Federal Government, states that "actions are under way to strengthen the Manpower Service in each state and locality with priority emphasis on placing rural residents and migrants in suitable jobs." These programs are designed to assist migrants and their families to settle out of the migrant stream by providing training and other assistance. I mention this item because it is consistent with national policy which has been to discourage the continuation of migratory labor in the United States. It is an item I think we have to take into account when we consider the outlook for seasonal farm labor supplies.

OPTIONS

Given the farm labor supply situation that is evolving, one would logically ask: what options are open to fruit and vegetable producers who need and depend on seasonal labor for successful operation of their farms? Obviously a number of options come to mind. These may range from efforts to initiate a new Bracero Program, to efforts to improve the terms of employment to make farm work attractive to more individuals. In this discussion I will only use one, a course that has been pursued by a group of California citrus producers in the Oxnard area. These producers, members of the Coastal Growers Association, about 10 years ago considered a number of courses that they might pursue upon the termination of the Bracero Program.

In 1965 the management of the Coastal Growers Association initiated a comprehensive program to restructure their recruitment, management, and compensation procedures to attract the kinds of workers they need to harvest their citrus on schedule and in the manner satisfactory to the management. An incentive pay plan was part of the package of terms that were offered to the workers. More importantly, management offered a substantial package of other benefits that attempted to make the work attractive to the employees. They attempted to build up a continuing relationship with their workers. They attempted to encourage the workers to identify with the Association and to think of the Association as their regular employer year in and year out.

Two elements of the labor management practices initiated by the Coastal Growers Association are of particular importance. First, personnel practices tended to decasualize seasonal farm work. Most seasonal farm workers in California agriculture are recruited and employed on a casual basis, with no continuing or recognized relationship between the worker and the job, and between the worker and the employer. The Association sought to encourage the worker to develop a permanent attachment to the Association. It was recognized that the work was seasonal, but an effort was made to lengthen as much as possible the period of employment. The fact that lemons are harvested throughout the year facilitated such an effort. Additionally, the Association structured its benefits to encourage employees to remain with the Association throughout the year and to return each succeeding year.

Secondly, coupled with and reflected in its pattern of benefits, the Association ap-

plied modern labor management procedures to the recruitment, employment, and supervision of employees. We can describe modern labor management as the application of science to the recruitment and the management of personnel, which simply means that we deal with workers as human beings. Modern labor management recognizes that workers as human beings have certain needs. When these needs are met, workers are more productive. These needs range from the physiological, such as food and shelter, to the more abstract requirements, such as the need for self-esteem and recognition.

Lemon harvesting is not generally regarded as a skilled task, yet carefully drawn up job descriptions were prepared which describe precisely what the job of a lemon harvester is. The employee is trained in lemon harvesting. Job training is developed so that workers may understand exactly why various requirements are imposed on picking methods. The worker understands why the fruit is handled in a specified way. In addition a system of worker supervision and performance evaluation is followed. To put it simply, the worker is treated with dignity, the job is treated as being important, the worker knows precisely what he is to do, he knows when he is doing a good job and he is compensated for productivity. Average earnings in 1973 were slightly more than \$3.00 an hour.

The personnel practices plus the package of benefits offered the worker tend to build a continuing relationship between the worker and the employer. Further, the package of benefits and personnel management procedures are structured to take into account the cultural background of the worker. More than 30 benefits are offered the workers. Some of these benefits are merely procedures and policies of the Association, such as a suggestion plan, employee newsletters, birthday greetings, and special leave permits. Benefits also include paid vacations, health and hospitalization, influenza shots, life insurance, savings and retirement plans, minimum wage training guarantee, adult education, counseling and legal aid, housing, and training and work improvement. In 1974 unemployment insurance was added to the list of benefits.

It would take some time to review the various benefits in detail, but we can answer two questions that reveal a great deal about the success of the program. The first question: Was the organization able to recruit enough workers to harvest its crop on schedule and in a manner satisfactory to the management? The answer to this is "yes"; in fact, it is more than "yes". The organization was able to secure enough workers to harvest its crop on schedule and in a manner satisfactory to management without out-of-state recruitment and without use of illegal immigrants. Further, because the productivity of workers increased substantially, it was possible to harvest the crops in successive years with a smaller number of workers. In 1965, 8,517 pickers were employed to harvest 4,358,000 boxes. In 1972, 3,335 pickers were employed to harvest 6,950,225 boxes. A second question should be asked, what happened to the cost per box under this elaborate program? In 1966 the total cost per box including direct and indirect costs was \$0.606 per box; in 1972 the total direct and indirect cost per box was \$0.682 per box. This was a modest increase in cost per box, but it was substantially less than the increase in the cost of living index during this period. In fact

if we deflate this cost per box by the index of the cost of living, we would discover that the real cost per box declined in the period 1966-1972 (9).

The results obtained from application of modern labor management in this case are impressive. We do not have analyses in detail of other applications of modern labor management to seasonal farm work although we are aware that a number of these have been in operation for at least as long as the case discussed here. We cannot assert that this approach to labor management would solve all seasonal farm labor problems for California agriculture or that this approach would be adaptable to every individual situation. It is questionable whether this approach could be expanded widely and quickly enough to substantially improve the labor supply situation that faces California agriculture in the summer of 1974. In general, programs such as this require careful planning. They cannot be implemented instantaneously. However, individual groups of growers who have clearly defined common interests would be in a favorable position to implement such innovations as those carried on by the Coastal Growers Association.

It should be emphasized, however, that the seasonal labor problems facing California agriculture are pervasive and complex. I do

not want to imply that the one approach that I have discussed here is the total solution to the emerging labor supply situation. I have discussed it because it is one illustration of an approach that has been pursued successfully by one group of growers.

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EXPERIENCES OF A LOCAL DATE GROWER AND PACKER IN PAKISTAN AND KENYA

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ABSTRACT

Date palm culture in Pakistan and Kenya is discussed, especially in relation to FAO/UN projects in those countries.

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It is an honor to be asked to speak today at the 1974 Date Institute. I must apologize for not coming prepared with slides and maps to illustrate my speech. My wife and I left Kenya a few weeks ago on leave before taking up another two year assignment with the United Nations Food and Agriculture Organization. We traveled light due to the fuel shortage and the chance of being bumped along the air route between Africa and California, so we didn't bring any files or any slides. In fact, I did not expect to give a talk on our experiences in Kenya and Pakistan, but while attending the National Date Festival I met our old friend, Roy Nixon, who informed me that the Date Institute was being held in March this year and that he thought I should tell of some of my experiences overseas. I will not give a very technical talk today, but instead will tell of some of our experiences and something about the countries where we worked.

DATES IN PAKISTAN

In 1962 we went to Pakistan to assist in setting up a date processing plant in the province of Baluchistan, which is on the border of Iran in the southwest part of what was then West Pakistan. Before we arrived, much preliminary work had already been done for us by our friend and colleague, Ted Carlson. Ted had made a survey for FAO of all parts of West Pakistan and had recommended that a date processing plant be set up in Turbat, Makran. Some of the finest dates in the country are grown there and the people need economic development. Turbat is in the province of Baluchistan, and it was here that the first FAO date packing house was established. Later, two more were built along the Indus river, one in the Sind at Khaipur and another in the northwest frontier at Dera Ismail Khan.

Pakistan has a rich heritage of history relating to the date palm. Date seeds at least 5000 years old have been found in storage godowns at Mohenjo Daro, the ancient city which has been unearthed along the Indus river in the Sind. Alexander the Great traveled through Pakistan in 326 B.C.; the remnants of his army were saved from starvation by dates obtained from the Ketch Valley in Makran as they traveled down the Makran Coast on their way back to Persia, where Alexander died. Mohamed Bin Qasim, the great Arab general, and his army ate dates as they traveled through Persia and Makran in 712 A. D. to the Indus valley where he introduced Islam to the sub-continent.

The origin of the date palm is lost in antiquity, but it is known that it flourished along the Tigris and Euphrates rivers in Iraq over 6000 years ago and presumably was spread over the sub-continent by man who dropped date seeds at watering places along the trade routes between the Indus river and the Tigris-Euphrates river systems. This probably accounts for the many varieties of dates because the same variety is seldom found in more than one area. It has only been recently, since the turn of this century, that man has to any great extent selected the best varieties and transplanted them to other areas. Even today in many parts of the Indus valley, especially north of the Sind, seedling date palms are found growing almost wild in clumps along river banks and on farms where surface water is available. The fruit is harvested, but little effort is made to improve production by selecting varieties. An exception must be made for Makran in Baluchistan, which is one of the most remote parts of the country. Here one finds date culture highly developed and hand pollination is practiced. Dates are definitely part of the staple diet of the people of Baluchistan, a wild country of rocky hills with few fertile valleys.

Dates in Makran are grown in the narrow river valleys between the ranges of hills where good alluvial silty land is available. Date gardens are not planted in solid plantations along the valley floor, but are found where water is available from the ancient karez systems. Some of the karezes are over a thousand years old, are rare feats of engineering, and have enabled the people of that desolate area to survive. A karez is developed by digging a well high on the alluvial fan at the mouth of a flood channel which emerges from the catchment area of the rocky hills. No mechanical means of lifting the water was available, so a tunnel was dug from the bottom of the well. The tunnel followed the hydraulic gradient down the slope until it emerged at the surface in the valley. Some of these karezes are 5 to 10 miles long and in Iran some are up to 70 miles long. When observed from the air, a karez looks like a series of gopher holes coming down the slope from the hills. In order to bring up the conglomerate of rock from the tunnels, a separate shaft had to be dug every few hundred feet. These karezes are generally owned by a group of families, each having a share; one share belonging to the family who dug the karez. The area of land farmed from one karez is naturally limited by the amount of water available. The water is supplied on the appointed day to each plot and strict rules govern its distribution. It is a very serious offense to cheat and obtain more water than one's allotment. Some of the better karezes discharge 1 to 2 ft.³ per sec. year round. All of this water is utilized to its fullest. The date palms are usually planted as a double-row border around small plots of about one-half acre, in which wheat, rice, alfalfa and vegetables are grown.

Few tractors are used in Baluchistan. Donkeys and camels are utilized to carry loads while bullock power is used to pull wooden plows which have steel pointed shares. Bullocks are an important animal to the people of Pakistan. They furnish the power to pull farm tools and also provide milk and meat. Considerable land is required to supply fodder for the bullocks, which must be fed year round.

Date harvest commences in June when the earliest varieties ripen and ends in December when the latest varieties are harvested. The people eagerly await the harvest season and the nomadic tribes arrive from the hill country to help harvest the dates. Nomads come with camel caravans carrying their entire possessions and set up camps around the edges of the date growing areas where they live during the harvest season. They are usually not paid cash to harvest dates, but take their pay in kind. When the nomads leave, they take with them dates packed in baskets, woven from the leaves of the dwarf wild palm, each of which weighs approximately 80 pounds. They load four baskets to a camel and head back into the hills with their flocks to follow the grass until the next date season.

Dates are harvested in several pickings during the season. They are picked when about half ripe and spread in the sun on mats in the growers' curing yards until they have reached the rutab stage. When the moisture content is low enough so that they will keep, the dates are pressed tightly into baskets. Usually one man pours the dates into the basket while another compresses them with his feet. In this way the air is forced out of the pack, which inhibits drying and, to some extent, discourages infestation by insects.

In the FAO packing house in Makran modern methods were introduced to this ancient land. The packing house was set up on similar lines to those found in the Coachella Valley. The plant was equipped with field boxes, fumigators, washing, drying and grading lines and a packing line where we packed in bulk containers and small half-pound packets. Dates were field graded in the growers' curing yards so that all the low quality fruit was removed. There was no problem, as all the low quality fruit was in great demand for animal feed. The fruit that came into the packing house was generally of high quality. The people adapted remarkably well to packing house routine, the women were exceptionally good graders, and the plant turned out a fairly decent pack. The fruit was then packed in cartons and shipped by truck about 400 miles to Karachi, which was the main date market and from there it was distributed throughout the country. Three local varieties of dates were packed, Begum Jungi, Husseni and Muzzawati, which we found suitable for processing and packing. In the Sind only one variety was packed, the Assil; in Dera Ismail Khan, we packed mainly one variety,

the Dhaki, a large, beautiful, amber date which brought top prices in the country.

In addition to setting up packing houses, I was also engaged in other related activities, such as selecting superior varieties for planting in Government Date Farms. More than 5000 offshoots of the varieties suitable for processing were planted in Government Date Farms at Bannu, Turbat, Dera Ismail Khan and Khaipur. Most of these are doing well and are producing offshoots for distribution to growers to help increase production and upgrade quality.

DATES IN KENYA

In 1969 FAO was asked to make a survey for the Government of Kenya to determine whether date culture would be feasible in that country. Kenya, located astride the Equator in East Africa, is a country of many contrasts from the lush green of the highlands, to the tropical coast along the Indian Ocean, to the arid wastes of the northern frontier. The arid northern regions have good soil and are provided with a few perennial and semi-perennial rivers, but little agriculture is known as this is the land of nomadic tribes and, until the recent drought when most of their cattle died, few attempts were made to grow crops. While coffee and tea are grown in the highlands, the lower, hotter regions grow mainly subsistence crops of maize, millet and sorghum. Few date palms are grown and little is known of date culture.

When I met the Minister for Agriculture in Nairobi, he informed me that they had imported some date palms during the second World War from one of the Middle East countries. The palms had grown well and flowered, but had produced no dates. He wanted me to go out and look at those

palms to find out why they were not fruiting, and said that if we couldn't find out why they were not fruiting, there was no reason to go ahead with the survey. We were flown to a place called Lokitauno, a police post on the Kenya—Sudan border. This is a hot, dry area of Turkana District near Lake Rudolf. We were accompanied by the Head of the Crop Production Division. After landing at the airstrip, we were transported to the police post up in the hills. We then walked to the place where the date palms were planted deep in a rocky gorge and stopped on a hill where we could look down on the date palms. I took out my binoculars and observed that the palms were planted along the banks of a stream. They were flourishing and had good-sized trunks and green fronds; they were also flowering. I told the Head of the Crop Production Division that it wouldn't be necessary to walk down there to determine why the palms weren't producing — I could tell from there. He said, "How can you do that?" I replied, "Well, they are all male palms." We then returned to Nairobi and met with the Minister to explain the situation. He laughed and said that it had taken them over twenty years to find out why those palms hadn't produced and it was apparent that they needed a specialist in date culture, so I should go ahead with the survey.

In the survey I found that the northern arid regions of Kenya had sufficient heat units to mature a crop of dates and that several areas along perennial and semi-perennial rivers would be suitable for propagation of date palms.

In 1971 the Government of Pakistan made a gift of 2000 date offshoots to the Government of Kenya. FAO was asked to collect the young palms and arrange transport from Pakistan to Kenya by sea. The offshoots were collected from Baluchistan and the Indus

Valley and transported to Mombasa via the Seychelles Islands. The palms were off-loaded at Mombasa and flown to Turkana by the Kenya Air Force in Caribou aircraft. Transport by road to this remote area could have proved difficult or even impossible, as the rainy season had arrived. The offshoots were planted along the Turkwell river on an FAO-sponsored irrigation scheme.

The project was not without problems. During the first 6 months the mortality rate was practically nil. Then many of the young palms began to show signs of weakness and lack of growth. Within a few weeks the new leaves in the crown began to rot. About this time an infestation of *Parlatoria* scale was found and a spray program was initiated to combat this pest; several pesticides including Chlordox, Diazanon and Rogor were used as sprays. The scale was controlled and some of the dying young palms began to revive. I then discovered that the spray program had inadvertently helped to control an infestation of termites that was contributing to the mortality rate of the palms.

There are now several small date plantations in northern Kenya and this year, three years after planting, several palms have bloomed and fruited. I look forward to some success in growing dates near the Equator.

In closing, I would like to say that the Date Institute Bulletins have been my best reference library throughout my 12 years with FAO. They contain information on all phases of the date industry, from intensive scientific research to practical hints for date growers. They have been a great help to me in my work as an advisor and I consider them the best source of information about dates. You are doing a great service. Keep up the good work!

BE THE MAN AT THE TOP -- BE A TREEMAN!

JOSEPH C. GENSKE

Representative of the Date Packers Council of California, Inc., 81-855 Hwy. 111, Indio, CA. 92201

Work in date palms for top pay. Experienced men can earn \$30 to \$50 per day. Trainees can earn up to \$20 per day. Year around jobs are available as well as part time. Get into this career field for good pay and security.

Moreover, experienced treemen enjoy on-the-ranch, family-style living. This is NOT a labor camp, busing-to-work, group-housing, central-feeding type of agriculture. And all of this is said for the purpose of making one point: "Mr. Treeman, you are the elite of the farm workers!"

Is this over-selling or merely stating facts? Well, let us look at some of the facts. In the Imperial Valley, farm labor is offered either free daily busing to the job — from the border at Calexico — or housing. There is, in addition, a guaranteed minimum wage. In the recent asparagus harvest, this was \$2.41 per hour. Hence, daily earnings tend to be in the range of \$16 to \$20 per day. Grape contracts were reported in the 1973 season as a minimum of \$2.40 per hour but piece-work brought this closer to an average of \$3.00 per hour.

In the date industry, however, in 1973, growers scrambled for the small number of treemen — only about 100 — and ended up with piece-work rates that resulted in daily earnings of \$30 to \$50. So, in giving publicity to the high pay and to the image that the treeman rightly deserves, our purpose is to attract enough treemen to reduce the scramble. In other words, by bringing the number of treemen closer to their demand, we should stop labor costs from moving to even higher levels. But equal with the issue of labor costs is the matter of getting enough treemen to get the crop bagged before that most dreaded of all things can happen: a rainy, humid period between mid-August and November.

Now, it can be asked, "If treemen earn more money than field workers, why are there so few of them?" The answer seems to be in this: one, the 1973 piece work rates were not known to either the recruiters in the Farm Labor offices or to the numerous "greencard" holders engaged in field work; two, these same people had a well-established belief that date growers would not hire anyone but experienced men, they would not accept a man for training; three, tree work does require a special type of man, one with strength, dexterity and no particular fear of working at heights. And then there is the resistance that comes from not understanding the need for this type of work. Why don't the growers cut off the tops of the palms so the fruit will grow lower

down? Why don't the growers chop down all the palms over 20 feet high?

Since mid-February, we have been working with the Coachella and the Calexico Farm Labor offices to change beliefs, publicize earnings and to solicit the help of the labor recruiters. We found them interested and willing, provided we could help them with some facts about our guaranteed minimum wage, housing, number of trainees we would take and whether we would provide transportation from the border.

Consequently, on February 27, a meeting was held of the principal growers of dates. Decisions were made that reflect this industry's desire to maintain an individual, instead of a centralized, approach to obtaining labor. For instance, busing labor from the border was rejected in favor of each grower paying the bus fare from Calexico for any man he hired. Once the man had a job, he would be deemed to be the same as the present treemen who arrange their own transportation for weekends at the border.

On a minimum wage, it was recognized that the State was moving to \$2.00 per hour, although 20 percent of the workers on any one farm could be trainees at \$1.70 per hour. The consensus at our meeting was that this industry should go to a straight \$2.00 per hour and guarantee 8 to 10 hours per day. In due time, and at key times of the year, the piece-work rate would move the men to a much better wage.

Regarding trainees, several large-volume growers, with experienced workers definitely stated they would accept men for training. Thus, the matter of taking trainees seems to be a problem only to growers without a nucleus of experienced employees.

Housing, too, is available on many ranches. Normally, this means space for men only, and it includes cooking facilities. It was agreed, however, that housing for families could be arranged, but this should be left to a deal between an individual grower and a worker. Throughout, it was understood that where five or more workers are to be housed on one ranch, the housing had to be certified as meeting State housing requirements.

With these areas of understanding, it was possible to expand recruitment from that already started in the production area — namely, spot announcements on radio with a request for workers to report to the Farm Labor trailer in Coachella — to the use of spots on Mexicali radio with the reporting to be the large Farm Labor facility right

on the border at Calexico. This facility, incidentally, is one you should see. It is staffed to receive job applicants, explain job requirements, select potential treemen, assist with transportation and generally carry out the task of assisting growers. The facility includes roofed assembly areas for workers and a great parking area for buses and cars. Looking southward, one can see the houses and the city of Mexicali. It is impossible to see this facility without remembering comments of Immigration and Customs officials who believe that the number of Mexicans with greencards — Immigration form I-151 entitling the holder to be a resident alien of the United States — is in the thousands. They reside in Mexico by preference or because annual earning do not permit their living in California.

In the week of March 5, spot calls for treemen began on Mexicali radio. These produced some results, responses from both experienced treemen and from men willing to learn. Our objective was to recruit about 40 full-time workers and about the same number of part-time workers. They were to come to the Coachella Valley in the current week of March 11. However, when some growers were contacted by the labor office, they requested delays of a week to ten days because the cool weather was holding back the bloom and hence the need for labor.

Another disrupting factor has arisen from the recent accidents involving bussed workers. The Farm Labor offices have been urged to insist on housing, and they are asking for this as a condition to referral of workers to date growers. Happily, most of the industry, in terms of volume of production, does have housing. The rest of you, if you want workers, would be well advised to set up housing or to rent it. I hesitate to say, however, that you might rent space in a farm labor camp. I suspect you cannot get treemen by offering labor camp housing.

Due to the hiring delay, I am unable to report on the total number of treemen our effort has produced for the industry. I do know that several ranches have hired men and more are available. I am convinced that all those who can frankly and fully cooperate with the Farm Labor offices will obtain desired manpower.

Finally, many of you have told me of your labor needs, and this information has been placed with the labor offices. If you have not done this, please call direct, 714-398-0276, and place your order. Be ready to tell Ernie or Joe, at the Coachella trailer, that you do have housing.

MEMBERSHIP ROLL 1974-1975¹

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